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Instrumentation

CONSTRUCTIVE criticism is always valuable and, therefore, members of the Scientific Instrument Manufacturers' Association who attended the recent convention at Harrogate must be well satisfied with the technical panel discussions that were held. For example, the increasing importance of standardization and inspection was stressed by one speaker, who cited instances of incompatibility within a range of standard instruments from one maker; identical plugs for the same type of instrument with the pin wiring different; performance in service as much as ten times below specification; and sometimes even instruments which do not appear to have been inspected at all before despatch.

Inadequate instruction manuals and data sheets came in for much adverse comment. Instances were quoted of one manual in which the supplier had omitted to furnish any information regarding operating voltage and frequency, and another in which the only co-incidental similarity to the instrument was the external appearance of the case. Among the many suggestions for their improvement was that they should be split into two completely separate sections—the first containing operating instructions for the user and the second, the servicing data. The ideal manual would use diagrams and photographs, not engineers' drawings, and would be bound in loose-leaf form so that revisions could be carried out easily. Data sheets should be comprehensive so that it should not be necessary to contact the maker of the instrument should the voltage of the supply or the pressure of the pneumatic system vary. In any case, users ought to be provided with reference photographs, so that should an emergency arise, telephone conversations with the manufacturer can be conducted intelligently; in this connection it was pointed out that one American firm was prepared to reverse the charges on any service call. Such is the diversity of form in which manuals appear, and remembering that good manuals can sell instruments, it would be profitable for S.I.M.A. to sponsor a committee to consider the adoption of a standardized layout.

Installation and servicing were also the subject of considerable criticism. On installation, particularly in the case of a complex instrument, the instrument operator and, if possible, the plant engineer ought to receive personal instruction from the instrument maker's engineer, and the importance of accessibility and the value of plug-in circuits cannot be over-stressed. The inclusion in the instrument itself of a circuit diagram on a P.V.C. sheet would also be valuable. On the question of servicing, one of the difficulties is that sometimes it involves the availability of specialized test gear so that the only solution is to return the instrument to the maker for attention. An ideal method of overcoming this difficulty would be to establish, by collaboration between the members of S.I.M.A., group service agents, trained in each of the collaborating firm's factories, who would be available to service locally certain classes of instruments made by any member of the group.

In general, it appears that this country is in advance of others on laboratory instruments, but not on quality measuring techniques on the plant, although we still have to import certain items such as colorimeters, balances in the kilogramme range and some kinds of thickness gauges. The main requirement which emerged in all the discussion was instruments with robustness and sensitivity. The value of scientific industrial instrumentation is fully realized by the major industries, but there is room for a great expansion in the smaller industries throughout the world which have not yet appreciated that instrumentation can save time and money. If British instrument manufacturers take the criticisms that have been advanced to heart and act on them quickly those markets can be theirs.

Out of the MELTING POT

Hybrids

HOWEVER distinctive processes for the working or fabricating of metals may be originally, continued development is bound to result in their tending gradually to shade over into one another. Indeed, the existence of a clear-cut distinction between some two processes may be taken as an indication that further development of both of them, and of the ground that lies between them, is called for. One such large piece of waste and largely unexplored ground is situated between casting and powder metallurgy. The fact that they are usually regarded as quite distinct is a sufficient indication and confirmation of this. Starting from the casting side, development towards powder metallurgy could, for example, introduce the principle of having the metal in small discrete units. These, in the case of casting, would be droplets of molten metal. The casting of metal droplets, with progressive though not necessarily immediate solidification of the cast metal, could be used to avoid the familiar difficulties associated with the solidification of large volumes of metal. Starting from the other side, development of powder metallurgy in the direction of casting could certainly start with the introduction of melting, with the consequent elimination of the familiar difficulties associated with the moulding of powders; the need for high pressures, non-uniform pressure distribution and consequent size limitations, and porosity of the compacts. That melting need not mean casting is to be seen in the case of a process which includes the compacting into a billet of a metal powder containing a non-metallic constituent. This billet is then heated to just above the melting point of the metal or alloy and then formed to the required shape by casting, pressure die-casting, or in some other suitable way, the whole process being controlled in such a manner that the non-metallic material is present throughout in the form of a skeleton, which provides support for the metal when the latter is melted. While the process is particularly applicable to aluminium and aluminium alloy powders, in the case of which the supporting skeleton is formed by the natural oxide film present on the surface of the particles of the powder, it can also be used with other metal powders to which a suitable proportion of some non-metallic material (carbon black, alumina) has been added.

Where Needed

PLANS for making changes usually take more or less for granted the need for the changes that are envisaged. If the changes are clearly for the better, taking the need for them for granted should require no further consideration. While this is clear enough, the obviousness of the next conclusion, namely that, since a change is desirable, the necessary action should be taken to bring it about, is possibly a little less obvious than it might seem. It fails, for a start, to admit any consideration of the fact that any problem, including that arising from the need for a change, sooner or later either ceases to be a problem or finds a solution. Given this self-eliminating or self-solving characteristic of problems, is it invariably necessary to expend efforts on their solution? Besides, if it is decided that such efforts should be expended, there remains to consider whether this very necessity for them might not be an indication that the solution—in the case under consideration the bringing about of the desired change—will not be premature and, therefore, not really all that could have been desired? A second consideration with regard to changes is the fact that changes are additive. The given change may be excellent in itself, but taken together with all the other changes that are being effected all the time, it may well add up to one of those good things that one can have too much of. A little study along the above lines is thus quite likely to show that a particular change could be left to look after itself instead of having time and effort expended on it and that, moreover, the change, if brought about as planned, would, in a wider context, add up to too much of a good thing. Having settled these questions, one might even go further and decide to use the time and efforts that have been saved for the purpose of preventing some changes from taking place or from being brought about by misapplied efforts.

Not Yet

ONE of these days, somebody, after surveying all the existing information, sorting fact from fancy, and after carrying out some experimental work of his own, will advance an explanation of the whole phenomenon of fatigue in metals which will differ from all the previous attempts in that direction in that it will be complete, correct and final. The prospect is not a pleasing one. Compared with the situation in which incomplete understanding is always inviting further study, speculation and comment, a subject of which there is complete understanding is fit only for textbooks and examination questions. Fortunately, the day on which the numerous research workers, now investigating various aspects of fatigue, will have worked themselves out of their jobs, is not yet here, and the pleasant possibility of watching their progress still remains. Beginning at the beginning, light has recently been shed on the way in which cracks originate in the region where a fatigue slip band emerges from the surface of the metal. The disturbances created in this region were observed at magnifications up to 20,000, achieved by optical microscopy combined with taper-sectioning. The observations showed that cracks developed quite early in the fatigue life, and supported the view that cracking is primarily a simple geometrical consequence of to-and-fro fine slip movements in the fatigue slip band. Another recent investigation, concerned with the effect of different atmospheres (air at different pressures, water vapour, inert gases and vacuum), dovetails quite satisfactorily with the observations just mentioned. This second investigation showed that microscopic cracks formed very early on in the fatigue life (after about one-tenth of the total life) of the test pieces, the time of their appearance being independent of the nature of the surrounding medium. This latter observation is in accord with the view that these initial cracks are formed by a purely geometrical-mechanical process. Later, the effect of the air was to speed up the propagation of the cracks. This effect was observed in the case of copper and aluminium, but not gold, and is ascribed to the attack of the gas on the highly strained metal at the tip of the crack, or to chemisorption of the gas on the surfaces freshly exposed by separation, this chemisorption rendering the separation of the surfaces irreversible.

Skinner

METALLURGICAL FACTORS AFFECTING SELECTION OF MATERIALS

Steels for Extrusion Tools

By F. RODGERS, A.Met. A.I.M.

(*Continued from* METAL INDUSTRY, 28 *November* 1958)

AS it is in intimate contact with the billet, the liner is subject to a complex combination of operational conditions. In order that it may give a good account of itself, it should possess the following properties at operational temperature:—(1) resistance to tempering; (2) resistance to heat checking; (3) ability to withstand operational stresses; (4) adequate resistance to hot abrasion.

Tempering of a hardened steel is a function of both time and temperature, and an empirical tempering relationship involving both time and temperature has been devised by Hollaman and Jaffe. Investigations have shown that those steels subject to secondary hardening tend to be structurally stable over relatively long periods of time. Steels of this type show a pronounced increase in hardness when tempered within the range 500°-550°C. The difference in the tempering characteristics of three typical liner steels is shown in Figs. 7, 8, and 9.

Reference to Tables I-IV shows that billet temperatures can extend over a very wide range, and it will be obvious that rigid standardization of liner steels is not possible. It is usual, when determining the most suitable steel, to take into account billet temperature, contact time, and extrusion rate, i.e. number of billets per hr. These factors determine the actual liner temperature.

It is pertinent, under this general heading, to also consider hot hardness, i.e. hardness at the expected operational temperature. There are several ways of determining this value, including Impact Brinell and mutual indentation, each of which has its own advantages.

Table VI shows the effect of time and temperature on the hardness of typical liner steels.

The extrusion liner is not subjected to violent temperature changes, ranging from high to low values, and heat checking in the normally accepted sense is not a major problem. This aspect is discussed in some detail in the section devoted to mandrels.

It is difficult to predict in precise terms the stress level in any part of the container assembly. This is particularly true in the case of the liner, due to the complex thermal pattern and the fact that, dependent upon individual circumstances, a portion of the liner may suffer plastic deformation. It is interesting to study in some detail the probable pattern of stress to be expected at the 75 per cent stroke position of a liner employed for the extrusion of a copper-base alloy, a circumstance that can induce a liner surface temperature at that position of, say, 550°C. In the off-load position, the liner will be in compression, and introduction of a hot billet will cause an increase in the surface temperature of the liner, with a slight increase in the compressive stress. Application of the extrusion load will reduce this compressive stress, and probably induce a tensile stress pattern. During the course of the extrusion cycle, the temperature of that part of the liner still in contact with the billet will increase, and it is highly probable that plastic deformation of the inner surface of the liner will occur. Immediately the ram has passed the selected position, the stress again reverts to one essentially compressive in character, and possibly of such magnitude as to cause a decrease in the bore of the liner by the mechanism of plastic flow. It is conceivable that, should this happen, the next operational stroke will remove, by the mechanism of hot abrasion, a thin sliver of metal from the liner wall which, in successive strokes, will create a cavity in the liner bore.

It will be obvious that local deterioration of the liner bore will proceed at an increased rate by the mechanism of "dovetailing," or keying of the billet into this cavity, causing extremely rapid liner failure.

TABLE VI—EFFECTS OF TIME AND TEMPERATURE ON HARDNESS

Brand	Type (per cent)	Hardness Values (Brinell)		
		Fully Hardened	Tempered at 550° for	
			1 hr.	106 hr.
Hecla 74	2 Ni-Cr	601	363	235
Hecla 135B	2 Ni-Cr-Mo-V	601	401	375
Hecla 168	1½ Cr-Mo-V	555	444	401
Hecla 174	5 Cr-Mo-V	515	530	375
Hecla 160	4 W-Cr	578	477	375
Hecla 149	10 W-Cr	415	477	352

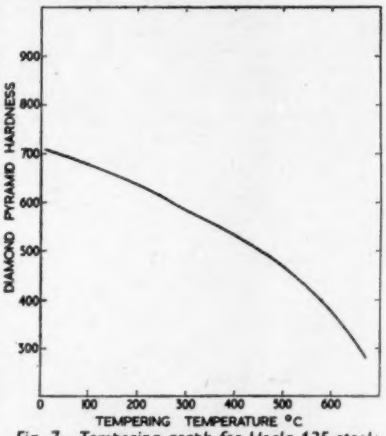


Fig. 7—Tempering graph for Hecla 135 steel: 1½ in. specimens 850°C., 30 min. oil quenched, tempered 1 hr.

Fig. 8—Tempering graph for Hecla 149B steel: 1½ in. specimens preheated at 850°C. for 30 min., raised to 1,125°C. for 15 min., air-cooled, double tempered

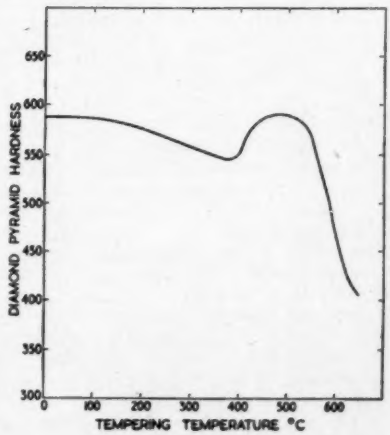
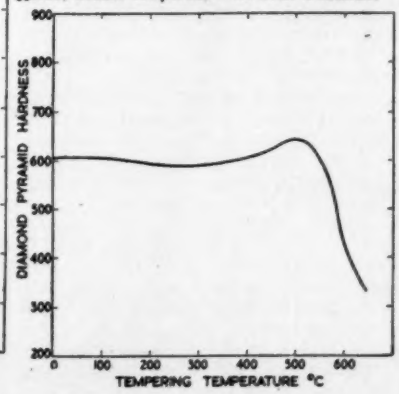
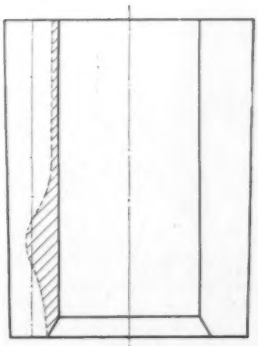
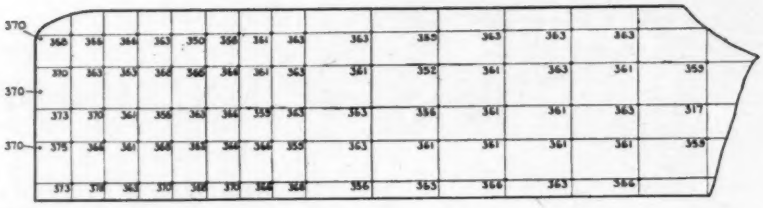


Fig. 9—Tempering graph for Hecla 174 steel: 1½ in. specimens preheated at 800°C. for 30 min., raised to 1,000°C. for 15 min., air-cooled, double tempered, 1 hr. each treatment

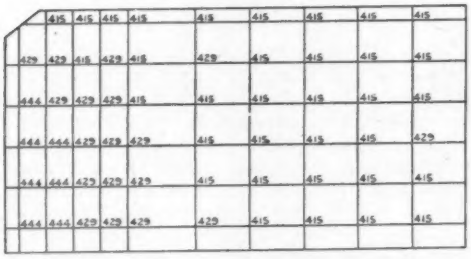






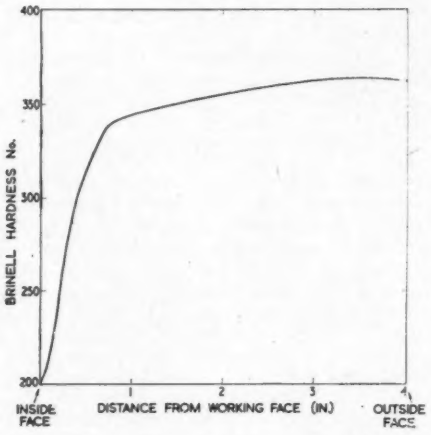
Left: Fig. 10—Probable isothermal pattern in wall of liner

Above right: Fig. 11—Brinell hardness trace through wall of extrusion press liner of Hecla 135 steel, after 9 months use in the extrusion of aluminium



Left: Fig. 12—Brinell hardness traverse across liner made from Hecla 174 steel

Right: Fig. 13—Brinell hardness through wall of Hecla 160C steel liner



Constant research into the properties and potentialities of cutting tools has done much to improve our knowledge of the various problems associated with abrasion at elevated temperatures. These researches have shown that certain elements, amongst which may be mentioned tungsten, molybdenum, chromium and vanadium, have, by virtue of their tendency to form refractory carbides, the ability to confer upon a steel the property of hot hardness. Other alloying elements, such as cobalt and nickel, can be used to strengthen the matrix.

The liner, during its service life, is subjected to stresses demanding considerable elastic or plastic movement, and thus, due regard must be paid to the desirability of ensuring that it possesses adequate ductility. Experience on a limited scale has shown that those steels containing 14 per cent tungsten or more are not sufficiently ductile for this duty, and it is not usual to employ steels of a higher tungsten content than 10 per cent. High-tungsten steels are only shown to their best advantage in the extrusion of high temperature metals such as steel, or, in certain instances, where abnormal contact times are encountered in copper-base alloy extrusion.

In the vast majority of cases where the workpiece is a copper-base alloy, steels containing 3 per cent tungsten, 1½ per cent chromium, and optional additions of vanadium and/or nickel, have proved to be equal to the more expensive 10 per cent tungsten grades.

Much interest has been displayed in the potentialities of the 5 per cent chromium family of steels in the form of liners for the extrusion of copper-base alloys and, within certain limitations, they give a good account of themselves. As might be expected from the tempering characteristics of this steel, it is very susceptible to softening at temperatures in excess of 600°C. approximately, based on normal tempering times. Allowance for the time factor indicates that it will suffer failure of a near catastrophic nature when the liner temperature exceeds 570°C. approximately, and operational experience has shown this to be the case. It is, therefore, essential, when contemplating the use of this type of steel, to give careful thought to the individual operational condition.

The conditions associated with the extrusion of light alloys are not unduly severe in respect of temperature, and experience has shown that a 2 per cent nickel-2 per cent chromium steel is quite adequate for this duty.

The extrusion of lead in the form of pipe or cable covering presents a unique problem in that the lead is generally introduced in liquid form, and it is not unusual to employ an inclined feeding chute for this purpose. An immediate effect of this is to expose a localized area to violent temperature fluctuation, and thus induce conditions favourable to the onset of thermal crazing. Experience has shown that, in such cases, it is desirable to reduce the hardness level of liners of the 2 per cent nickel-2 per cent chromium type so as to enhance the ductility at some expense of wear resistance.

These considerations lead to the conclusion that the choice of liner material is not determined by any single factor, and it is pertinent to this problem to give some thought to the probable thermal pattern existing in the liner. The path of an arbitrary isothermal will probably take the form indicated in Fig. 10, the dip towards the die arising from end effect.

In the case of light alloys, where the container is heated to a temperature approaching that of the billet, the liner will be maintained at a near constant temperature, and temperature variations will be small.

The actual level of the isothermal will depend upon individual considerations, and it is reasonable to assume that the elastic/plastic boundary will follow a similar pattern. An interesting case arises when the liner, due to stress and/or temperature, is plastic throughout the thickness of the wall, as shown by the dotted line in Fig. 10. Under such conditions the liner itself will tend to extrude, and instances of this have been known, particularly where the liner has been of the thin-wall type. The dangers associated with fully plastic behaviour of the liner are fully recognized, and present the main objection to the use of thin-walled liners for hot extrusion purposes.

An actual hardness trace through the wall of a liner in Hecla 135 steel after nine months' service in the extrusion of light alloys, is shown in Fig. 11. The initial hardness was 429 Brinell approximately, and it will be observed that whilst the hardness has decreased, the resultant values are reasonably uniform.

A similar hardness trace through the wall of a liner in Hecla 174 on completion of its normal life in the extrusion of a copper-base alloy is shown in Fig. 12. The initial hardness was 444 Brinell approximately, and in this case it will be observed that the hardness pattern is similar in many respects to that predicted by the isothermal shown in Fig. 10.

It will be appreciated that abnormal contact times due to stickers, etc., can result in marked deterioration of the liner due to softening. The hardness variation through the wall of a liner

TABLE VII—LINER STEELS

Mark	Analysis (per cent)								Typical Application
	C	Si	Mn	Cr	Ni	Mo	W	V	
Hecla 149	·40	·30	·40	3·0	—	—	9·5	—	Steel
Hecla 149B	·35	·30	·40	3·5	—	·50	9·5	—	
Hecla 149C	·35	·30	·40	3·5	—	·50	9·5	·40	
Hecla 160B	·40	1·0	·40	1·5	—	·50	3·5	·60	Copper- and Nickel-base alloys
Hecla 160C	·40	1·0	·40	1·5	—	·55	3·5	·25	
Hecla 174	·40	1·0	·40	5·0	—	1·4	—	·90	
Hecla 177	·40	1·0	·40	5·0	—	1·4	1·2	·20	Copper- and Aluminium-base alloys
Hecla 135	·60	·30	·30	2·0	2·0	·45	—	—	
Hecla 168	·50	·80	·65	1·5	—	·40	—	·25	

TABLE VIII—STEELS FOR STEMS

Mark	Analysis (Approx.) (per cent)				
	C	Mn	Cr	Ni	Mo
Hecla 67B	·30	·40	1·25	4·0	·40
Hecla 74	·60	·20	2·25	2·25	—
Hecla 135	·60	·20	2·0	2·0	·50
Hecla 174	·40	·50	5·0	1·4	·90

in Hecla 160C steel after the occurrence of such a mishap is shown in Fig. 13.

It is not surprising to find a wide variety of steels in current usage for liners, and the list shown in Table VII is by no means complete.

Extrusion Ram or Stem

The stem is protected from direct contact with the billet by the pressure pad, and extensive investigations have shown that, even at the nose, the temperature is not likely to exceed 360°C. In service, it is subject to a compressive stress which may approach 80 tons/in², thus it is essential to employ steels capable of absorbing these stresses elastically. In the determination of a suitable steel it is necessary to consider—(a) the operational stress; (b) the effective mass of the stem; and (c) the tempering temperature of the steel.

The calculation of the operational stress is a simple matter, and the value can vary from 30-80 tons/in², depending upon the material being extruded. The major problem arises in the higher stress range, and is aggravated by the fact that the ram may, in some cases, have an effective diameter of 20 in. or more. It will be evident that, in order to meet these extremely onerous conditions, steels having tensile strengths of the order of 100 tons/in², with corresponding yield points of 80 tons/in² must be employed. This requirement can only be realized by those steels having both a high hardenability and a high hardness level after the application of a suitable heat-treatment, and the manufacture of such highly stressed components demands careful control.

Analyses of steels widely used in the form of stems are shown in Table VIII.

Hecla 67B corresponds to Specn. En.30.B, and suffers the disadvantage that it is very susceptible to softening, and the requisite tensile level can only be attained by tempering at 200°-250°C. Its use, therefore, is limited to certain specialized applications.

It has been stated above that the operational stress can be of a very high order, and the metallurgist, when selecting his steel and tensile or hardness level, must guard against upsetting or mushrooming, on the one hand, and tendency to brittleness on the other. Experience has shown that for many applications a hardness approximating to 500 Brinell is desirable, and as the steel at this hardness level permits of little plastic deformation, particular attention must be paid to those design features capable of serving as stress raisers. A typical extrusion stem, which incorporates stress raisers capable of initiating failure, is shown in Fig. 14.

The recess at the nose of the stem is often threaded to accommodate a plug used to locate the pressure pad, and failure by fatigue at this point is occasionally encountered. The mal-effect of this feature can be minimized by the use of a tapered recess of the type shown in Fig. 14(a); the plug can be made in mild steel and driven into the recess. Failures have also been attributed to the lack of a suitable radius at the junction of the stem and its tapered head.

Instances have also arisen when failure of hollow stems has occurred due to bending of the pad, and the consequent generation of high radial stresses in the stem wall. This is demonstrated in Fig. 14(b).

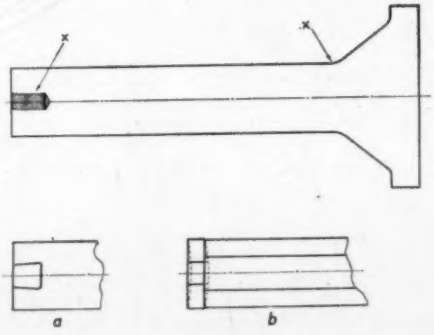
It is essential to avoid stress raisers in the form of machine tool marks, so that every effort should be made to ensure that a smooth and uniform finish is obtained.

The hot tensile properties of two steels widely used in the form of extrusion stems are shown in Fig. 15.

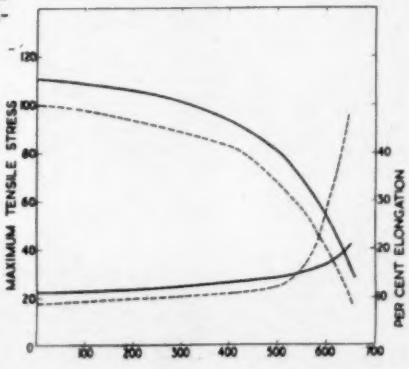
In some cases, particularly where the practice of back extrusion over the ram is used, it may be necessary to consider the effect of crippling. Lack of precise knowledge regarding the state of freedom of the ram again creates a problem that defies mathematical solution, but it would appear that a length : dia. ratio of 7 : 1 is acceptable.

Mandrel

The mandrel, essential to the production of most tubular sections, is subject to a very complex set of conditions. During a normal extrusion cycle it must generally pierce the billet, maintain its dimensions whilst the



Left: Fig. 14—Extrusion stem



Right: Fig. 15—Effect of temperature on tensile properties

section is extruded over it, often submit to drastic cooling, and occasionally suffer rough and ready straightening during service. In more precise terms, it should possess the following properties: (a) hot strength; (b) resistance to hot abrasion; (c) resistance to heat checking; (d) resistance to tempering; (e) resistance to fracture.

It is hardly surprising that the perfect mandrel steel awaits development, and, in the meantime, recourse is generally made to the tungsten or the 5 per cent chromium series of steels.

The forces exerted on the mandrel during service are complex in character in that they are compressive in the radial direction, and tensile in the longitudinal direction. In addition to these service stresses are those associated with the thermal effects arising from cyclic heating and cooling, which, in the case of water cooling, can be appreciable.

The stress patterns created in the mandrel by heating and cooling are demonstrated in Fig. 16; the actual values will be determined by the diameter of the mandrel and the rates of heat transfer. It will be seen that inability of the mandrel to absorb these stresses, either elastically or plastically, can result in cracking in a longitudinal direction during the cooling cycle. The development of surface imperfections, in the form of either longitudinal splits or fire cracking, will adversely affect the frictional forces between the mandrel and the workpiece, thus increasing the tensile force acting on the mandrel to such an extent as to cause local deformation or necking. Local loss of diameter of the mandrel will permit of mutual keying or dovetailing of the billet at that particular point, and failure by the mechanism of inadequate hot tensile strength will occur.

The problem of surface cracking under conditions involving cyclic heating and cooling is encountered in many applications, including die steels, hot rolls, etc.; thus, it is not surprising to find that it has been the subject of much research work. The company with which the author is associated has devised a piece of equipment intended to investigate this property, and this is shown in Fig. 17.

The apparatus is actuated hydraulically and controlled by a solenoid, the arrangement being such as to permit of its application over a wide range of heating and cooling rates. Experience has shown that a specimen of the type shown in Fig. 18, with its sharp change in section, accelerates the onset of cracking at the edge.

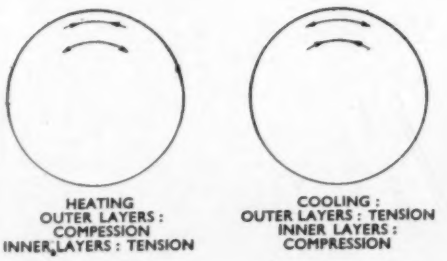
The consensus of opinion is that, in the absence of any surface attack by the mechanism of solution or intergranular manifestation, failure is by the mechanism of fatigue, and an order of superiority can be established for any particular set of conditions. Adjustment of these conditions, however, in respect of the temperature limits or the cyclic rate, can profoundly affect the result; thus, a steel possessing marked superiority between the extremes of, say, 550°C. and 20°C. may be inferior between the extremes of, say, 600°C. and 100°C.

During the course of early investigations, it became apparent that the 5 per cent chromium-molybdenum-vanadium steel represented by Hecla 174 was a good general-purpose steel for cyclic heating and cooling within the temperature limits expected of mandrels used in the extrusion of copper-base alloys. Operational experience with this steel has, in the vast majority of cases, proved very satisfactory. Steels of this type do not, however, possess the hot strength of the 6 per cent to 10 per cent tungsten series, and it is essential to employ water or other form of cooling between cycles so as to maintain the actual mandrel temperature at an acceptable level.

In certain cases, cooling of the mandrel may not be practicable, or in others the actual mandrel temperature may exceed the limitations of the 5 per cent chromium-molybdenum-vanadium steel. It then becomes necessary to take advantage of the hot strength of the tungsten series of steels, and a number containing 4 per cent to 12 per cent tungsten with other alloys, such as chromium, molybdenum and vanadium, are available. These steels are subject to brittle failure over a relatively wide temperature range, which increases with the tungsten content, and, therefore, do not lend themselves to drastic cooling. On the basis that the carbon content is within the normal limits, it is generally found that those mandrels containing up to 6 per cent tungsten can be oil-cooled, whilst those containing above 6 per cent tungsten should be air-cooled.

The tendency of the higher tungsten steels to fail in a brittle manner, even at relatively high temperatures, requires that in the interests of longevity they should be preheated so as to reduce the effects of thermal shock. Opinions differ regarding the benefits to be derived from the preheating of mandrels manufactured from the 5 per cent chromium-molybdenum-vanadium series of steels, but it is generally accepted that it is not as necessary as in the case of the tungsten steels.

Fig. 16—Behaviour of mandrel during heating and cooling cycle



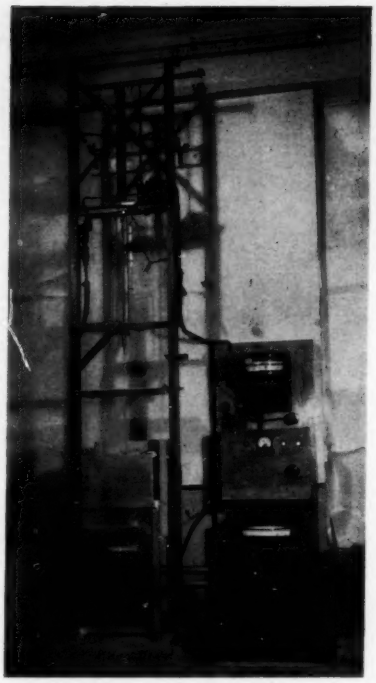


Fig. 17—Equipment for investigating surface cracking under conditions involving cyclic heating and cooling

The conditions encountered in the extrusion of light alloys are different in that the mandrel temperature must approach that of the billet, which, in the majority of cases, approximates to 450°C. This temperature is not such as to demand the hot strength of the higher tungsten steels, and the 5 per cent chromium-molybdenum-vanadium or the lower tungsten steels are widely used.

The mandrel often has a large length:diameter ratio, and in the event of slight misalignment, the junction of the mandrel and its head can be subject to large bending stresses with possible fracture in this area. Experience has shown that very real

Fig. 18—Repeated quench test specimen

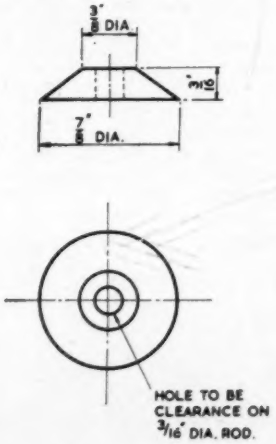


TABLE IX—STEELS FOR MANDRELS

Mark	Analysis (per cent)					
	C	Si	Cr	Mo	W	V
Hecla 174	·40	1·0	5·0	1·4	—	·90
Hecla 176	·35	1·0	5·0	1·1	5·0	·50
Hecla 177	·40	1·0	5·0	1·4	1·2	·20
Hecla 160C	·40	1·0	1·5	·50	3·6	·20
Hecla 149B	·30	—	3·75	·50	9·5	—
Hecla 149C	·30	—	3·75	·50	9·5	·40

TABLE X—TYPICAL DIE STEELS

Analysis (per cent)						
C	Cr	W	V	Co	Ni	Mo
·40	13·0	2·50	—	—	13·0	—
·40	13·0	1·30	1·20	—	13·0	—
·35	2·50	9·00	·40	2·50	—	—
·40	3·00	—	·40	—	—	—
·40	1·50	5·00	·50	—	—	—
·40	1·50	·50	1·00	—	—	·50
·40	1·00	4·00	—	—	—	—
·40	5·00	—	·40	—	—	1·30
·40	5·00	—	·80	—	—	1·30
·40	5·00	5·00	·40	—	—	·90
·35	2·5	1·80	1·00	—	4·50	—
·65	1·50	2·50	·25	—	—	—

advantages can accrue from differential softening of the head, and resultant widening of the plastic range.

Typical mandrel steel analyses are shown in Table IX.

Extrusion Dies

The extrusion die determines the shape of the product as it leaves the press, and thus little wear or surface irregularity can be tolerated. It is a costly and very expendable item, and both users and manufacturers are constantly examining new possibilities. As would be expected, the severity of the problem increases with the temperature of extrusion, and whilst some alleviation has been brought about by the use of lubricants such as glass for very high temperature extrusions, there is still considerable room for improvement in this field.

The application of the process of precision casting to small dies, and the development of spark and other special machining methods, have permitted the use of cobalt-base, nickel-base, and high-strength austenitic steels. These, together with the more conventional die steels, present the user with a formidable array of materials, which fall into well-defined categories.

The various factors that can affect die life are:—(1) hot abrasion; (2) lack of hot strength; (3) tendency to crack; (4) lack of support by the die holder.

Resistance to hot abrasion is associated with the form, distribution, and type of carbide, and in this respect those alloys containing tungsten carbide in a cobalt or other non-ferrous matrix are outstanding, particularly in the higher temperature ranges. They suffer the disadvantage, however, of lack of ductility, particularly at room temperature, and it is essential that they receive adequate support in service.

This shortcoming has aroused interest in the potentialities of austenitic steels as, by careful selection of composition and manufacturing procedure, suitable hot strength characteristics can be realized. These steels do not exhibit enhanced resistance to hot abrasion, but have the property of resistance to washing.

The selection of a die material is governed by many individual circumstances, amongst which may be mentioned shaping facilities, heat-treatment facilities, and, in the case of precision castings, the demand for any one section. It will be appreciated that, metallurgical considerations apart, these factors play a major role in determining the most suitable material and, despite the challenge of alloys, basically non-ferrous in character, there is still a heavy demand for tool steels in the form of dies. Die steels may be divided into well-defined categories as follows:—

(1) 5 *per cent Chromium and Allied Steels.* The 5 per cent chromium steels, further alloyed with molybdenum, vanadium and tungsten in varying combinations, are primarily suited to the extrusion of aluminium-base alloys, a duty within their capabilities as hot die steels. They are not so prone to the mal-effects of segregation as the high tungsten steels, and enjoy a good measure of success in the form of port hole dies.

In certain circumstances they have given a good account of themselves in the extrusion of simple sections in the less refractory copper-base alloys.

(2) 2 *per cent Tungsten Steels.* This class of steel, again, is used for the extrusion of light alloys.

(3) 8 *per cent to* 10 *per cent Tungsten Steels.* This family of steels is widely used for all types of extrusion dies, and there are many variants of the basic composition. The hot hardness is adequate for most purposes, and it has established itself as a well-tried general purpose die steel. In common with other high tungsten steels, it suffers lack of ductility over a wide temperature range, and there is a marked tendency for dies to crack at the corners essential to many extruded sections. This tendency can, to some extent, be minimized by careful selection of hardness level.

(4) *Austenitic Steels.* These, in the main, are based on the 14 per cent chromium-14 per cent nickel series, with additions of tungsten and/or vanadium. Steels of this type are noted for their hot strength, as distinct from hot hardness, and find some application in the field of special purpose dies.

(5) *High Tungsten Chromium Steels.* Much interest has been displayed in the 12 per cent tungsten-12 per cent chromium series of steels, and under certain conditions they give a very satisfactory performance. The composition is such that, in the hardened condition, the structure is austenitic with islands of martensite. Tempering of this structure promotes precipitation within the austenite and, as would be expected, it exhibits pronounced secondary hardening. The position of this peak varies with small changes in composition, so that it is essential to know the characteristics of each cast of steel, and maintain the identity of each die. Overheating of the die in service can result in excessive softening, and this, together with the critical heat-treatment requirement, has not favoured the development of steels of this type.

The various problems concerning die steels are under constant investigation, and recent work has shown that the relative proportions of carbide formers, as distinct from quantity, does much to determine the suitability of a steel for this purpose. The future cannot be foretold with confidence, but there are some indications that future die steels will not be of the type dependent upon the austenite/martensite transformation, but rather upon precipitation from an austenitic matrix.

Table X shows the analysis of typical die steels.

The author would like to express his appreciation to Mr. E. W. Colbeck, metallurgical director of Hadfields Ltd., for granting permission to publish this work, and to certain of his colleagues who have assisted in its preparation. Acknowledgment for permission to include Fig. 1 is also made to the Loewy Engineering Co. Ltd.

Pressure Die-Casting Review

Die-Cast Cycle Bell Frame

The Adie cycle bell which uses a pressure die-cast frame for the assembly of the mechanism

RELATIVELY simple as it is, the mechanism of a bicycle bell would not be expected to provide the type of application in which a pressure die-casting would show its full advantages. However, the example shown here, one of the range of bells made by Adie and Nephew Limited, who specialize in this class of equipment, provides evidence to the contrary in that the use of a single zinc alloy die-casting for the main frame has eliminated some fourteen operations, thus simplifying production, and releasing press and machine capacity.

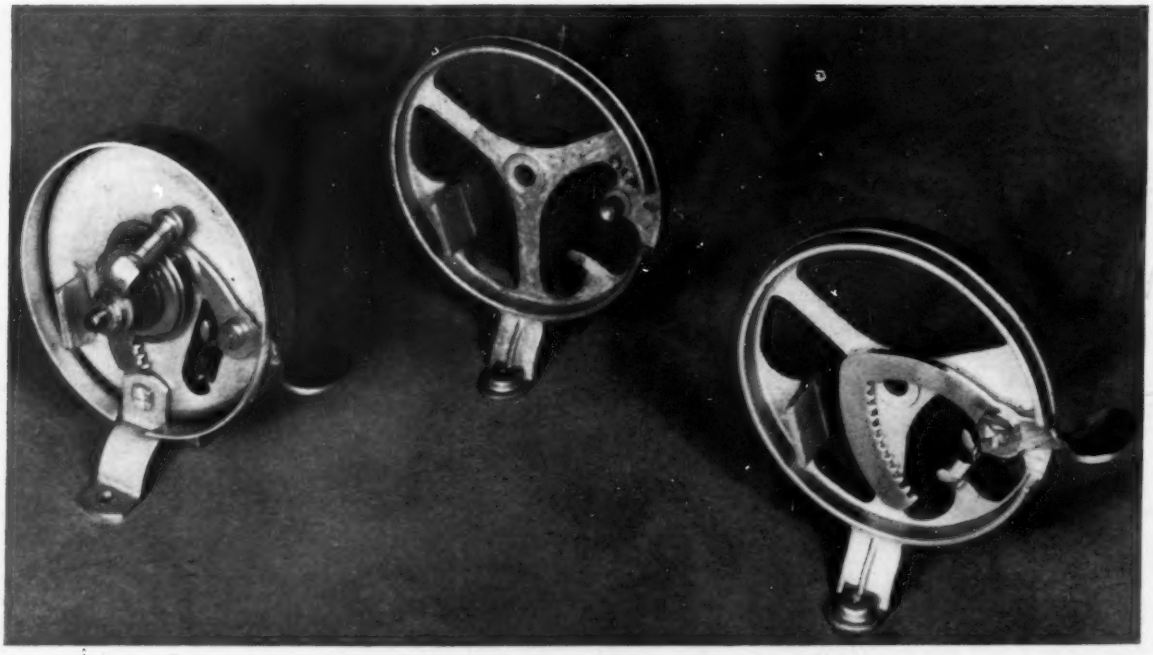
Prior to use of the die-cast frame, the assembly was built up as shown below on the left. This assembly constituted a platform or frame formed from mild steel, the first operation being cupping. The cup was then dished to provide the flanged platform. Five piercings were made in the platform, the flange being pierced in two places. A small web, blanked from mild steel, was pressed and staked into position in one of the pierced apertures in the platform, and two further pressings formed the fixed half of the bracket, these being riveted in position on the platform. A centre pillar was formed by riveting a bush in the centre hole. The working parts of the bell were then assembled on this base.

As a zinc alloy die-casting, the centre boss and bore are incorporated in the casting, as also are the web, the return spring hook, the lever pivot and the half bracket. Thus, the only operation required on the frame itself is the tapping of the two holes in the half bracket.

As can be seen in the partly-assembled frame on the right, the lever pivot is spread over a washer to retain the lever while allowing it to turn. The assembly of the striker mechanism is similar in both the pressed and the die-cast models.

Consideration of this assembly in both its forms shows very clearly the superiority of the die-cast product from the manufacturing angle. It is not a line for which there is a fantastic sale, so that the high production rates of which die-casting machines are capable have no relevance, yet, even in the medium-sized batches called for, the savings in machining and assembly time have more than justified the adoption of the pressure die-cast part.

Bell frames. Left: The original assembly of steel pressings. Centre: The pressure die-cast frame. Right: The assembly built on the die-casting



Induction Heated Die-Casting Machines

The application of induction melting and holding furnaces to pressure die-casting machines is described in this article which is abstracted from "Metalurizdat," Moscow. Particular interest attaches to the installations described, since some of them are of novel arrangement.

LOW-FREQUENCY induction furnaces have for some time been used in Soviet zinc alloy die-casting works both for remelting and on the actual die-casting machines. Their main advantage is that the temperature of the metal can be maintained within 1° or 2°C. of the optimum, thus minimizing any chance of iron pick-up.

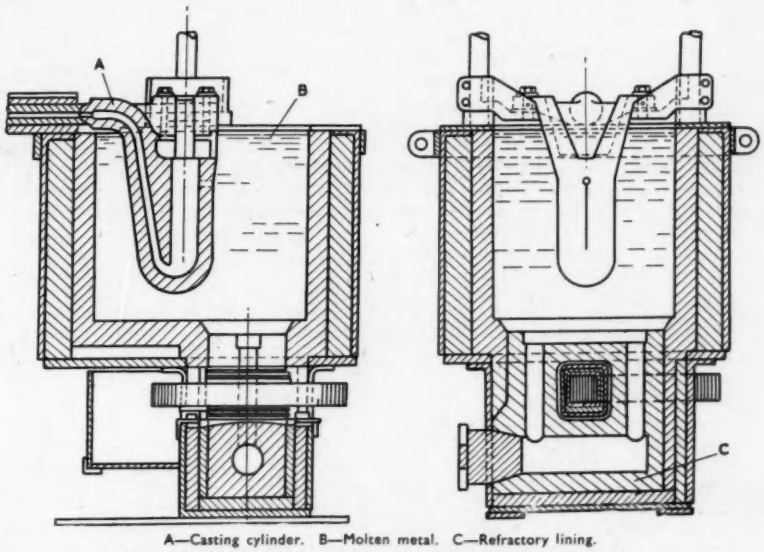
Melting furnaces are either single- or di-phase. A single-phase furnace with vertical channels is shown diagrammatically in Fig. 1; furnaces with horizontal channels are also used for zinc alloys. The vertical melting channels are joined at their lower ends by a very large horizontal channel, closed at one end by a plug. Since the molten alloys contain drosses, the vertical channels soon become choked, and for this reason rectangular channels are preferred, being easier to clear. It is also possible to minimize choking of the vertical channels by introducing, once or twice a week, a small quantity of ammonium chloride, which decomposes the iron compounds and forms compounds which are much lighter and rise to the surface of the bath, from which they can easily be skimmed off.

Two die-casting machines incorporating induction furnaces are shown in Figs. 1 and 2. In the first, the casting chamber and goose neck are situated close to the transformer, and are thus subjected to the influence of electrical and magnetic fields. In the furnace shown in Fig. 2 this fault is eliminated by placing them away from the influence of the transformer. This means, however that the distributing spout must be heated, this being done by electrical resistances.

An installation of ten die-casting machines is shown in Fig. 3, including two di-phase induction melting furnaces (each having a capacity of 1 ton of metal and a power of 60 kW) with a common reservoir (*B*) and five induction furnaces (*C*), each feeding two die-casting machines (*D*). The launder (*E*) is made in several sections, provided with resistance heating elements to prevent solidification of the metal. By this method of feeding, the molten metal is maintained at the same level in all the machines. Experience has shown that the induction furnace linings last for more than 900 hr. For zinc alloys the furnace lining is made up of the following composition: raw clay 35 per cent; burnt clay 53 per cent; kaolin 12 per cent. The clay itself is of the following analysis: SiO_2, 40 per cent; Al_2O_3, 36-75 per cent; $CaO+MgO$, 0·56 per cent; K_2O, 0·41 per cent; Na_2O, 0·37 per cent; H_2O, 11·87 per cent. Sulphite residues from paper making are used as binders. For the furnace covers, linings of the following compositions are recommended:—powdered diatomite, 40 per cent; burnt clay (2-3 mm. grain size), 20 per cent; fireclay, 20 per cent; silver sand, 20 per cent.

A completely automatic feeding scheme for two die-casting machines is sketched in Fig. 4. Each machine (1) is provided with an electromagnetic pump (2) injecting the required volume of metal at predetermined time intervals corresponding to the machine cycle. The liquid metal is fed to the casting chamber through an inclined launder (3), which in turn receives its metal from the induction melting furnace (4).

In induction melting of zinc alloys, the consumption of electricity in the

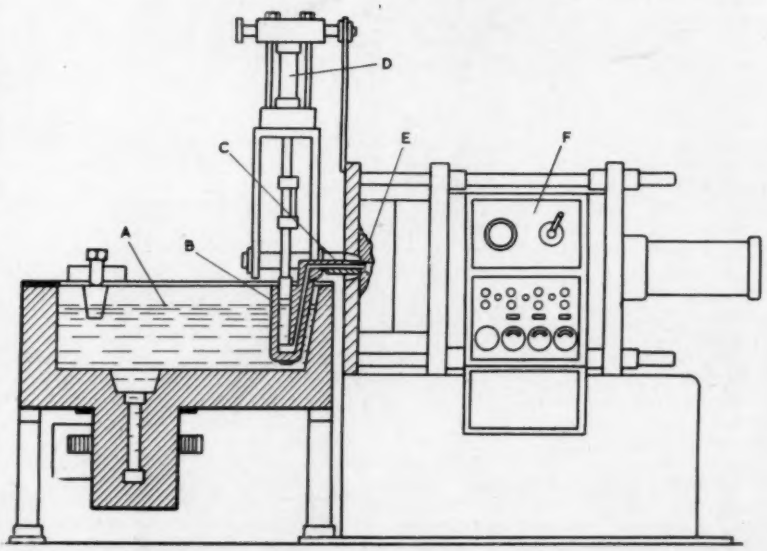


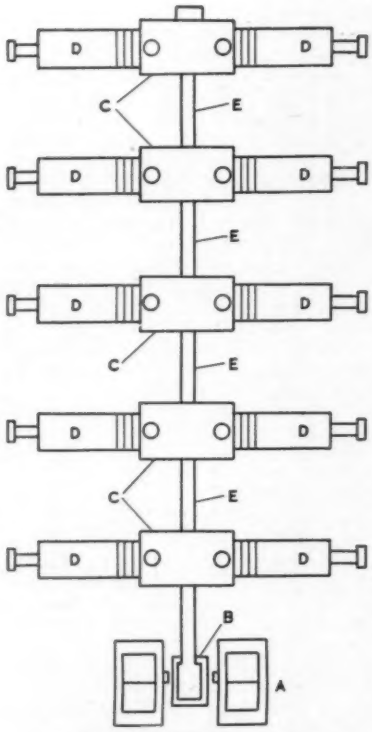
A—Casting cylinder. B—Molten metal. C—Refractory lining.

Fig. 1—Integral induction furnace for hot chamber pressure die-casting machine

Fig. 2—Improved design of induction-heated hot chamber die-casting machine

A—Molten metal. B—Casting cylinder C—Injection nozzle. C—Injection cylinder. E—Die. F—Control panel



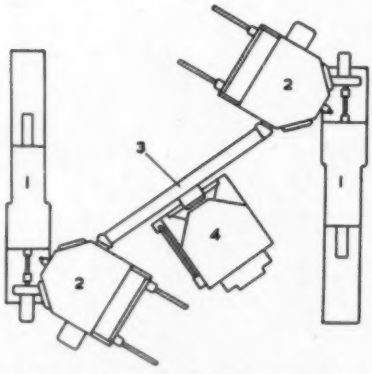


A—Di-phase induction melting furnace.
B—Common reservoir.
C—Induction furnaces (holding).
D—Die-casting machines.
E—Launder.

Fig. 3—Arrangement of a battery of 10 die-casting machines. Each pair of machines is fed from an induction furnace, in turn supplied by a launder that carries metal from a common reservoir between two di-phase induction melting units

larger furnace is about 125 kWH/ton of metal melted.

Induction melting of light alloys offers certain advantages, particularly less consumption of energy (425-480 kWH/ton of liquid metal against 650-700 kWH in resistance heated crucibles) and less metal loss by slag formation (0·5-0·8 per cent compared with 1·2-2·0 per cent in resistance furnaces and 3-4 per cent in fuel-fired furnaces). On the other hand, the alumina formed, being heavier than the metal, collects on the walls of the channels and leads to frequent stoppages. Mechanical cleaning of the channels is a complicated operation which should be carried out at least once or twice a day. Again, the life of the furnace lining is less and the current density allowable is low (3-5 amp/mm^2 against 12 amp/mm^2 for zinc), as is also the power factor (0.3-0·4). For melting aluminium, the furnace lining is composed of burnt clay containing 64 per cent SiO_2 and 36 per cent Al_2O_3 bonded with sodium silicate, and not more than 5 per cent water.



1—Die-casting machines. 2—Electromagnetic pump
3—Launder. 4—Induction melting furnace.

Fig. 4—Scheme for automatic feed for two die-casting machines

Men and Metals

Director of the British Cast Iron Research Association for the past 34 years, **Dr. J. G. Pearce** is retiring from that office at the end of this year. He will be succeeded by **Mr. H. Morrogh,** who is deputy director, and **Dr. H. T. Angus** will become deputy director. Dr. Pearce has served on many national and international committees and was awarded the O.B.E. in 1950 and the C.B.E. in 1957.

Recently resigned from the board of The Amber Chemical Company Ltd., **Mr. H. N. Wigan,** M.C., M.Inst.Pet., has joined the board of Combustion Chemicals Ltd.

Appointed to the newly-created position of senior sales co-ordinator of the Jenolite group of companies is **Mr. K. A. Clark.** The purpose of this new position is to augment the scope of distribution of the group's products and processes throughout the U.K., and to greatly improve its technical servicing facilities.

It has been announced that the board of the newly-formed company—Birlec-

Mr. G. P. Tinker

Efco (Melting) Limited—comprises **Mr. George P. Tinker,** as chairman; **Mr.**

Mr. J. C. Howard

J. C. Howard, as managing director; **Mr. F. S. Leigh** as assistant managing director; and **Mr. D. L. Campbell, Mr. J. H. Crossley, Mr. P. F. Hancock, Mr. J. A. Monks** and **Mr. T. G. Tanner** as directors. The secretary of the company is to be **Mr. J. C. Mantell.**

Mr. F. S. Leigh

In order to streamline their outside representation, Fielden Electronics Limited have formed three new sales divisions. **Mr. R. Speller** becomes manager of the London division; **Mr. F. G. Totty** is to be North-Eastern division manager, based on Stockton, and **Mr. F. B. Price** to be manager of the Midlands division.

After a long association with the Brockhouse Organization, **Mr. A. Trevena** retired last month from his position as works manager of Thomas Chatwin and Company, which firm he joined over thirty years ago. Succeeding Mr. Trevena is **Mr. E. S. Broxton,** who has been assistant works manager for several years.

News from Research and Control Instruments Limited is that **Mr. K. S. Phillips,** B.Sc., A.C.G.I., A.M.I.E.E., has been appointed sales controller to the company. Among other duties he will be responsible for the co-ordination of all sales staff activities.

Appointed field sales executive to Steels Engineering Products Limited, **Mr. W. D. Cartwright** will be attached to the staff of the home sales director at Sloane Street, London, S.W.1. Prior to this appointment Mr. Cartwright was with R A. Lister and Company Limited, of Dursley, for eight years.

Awarded the Silver Medal of the City and Guilds Institute, **Mr. William S. Poxon,** assistant chief metallurgist of Guy Motors Ltd., has obtained a First Class Pass in each of the four sections of the examination. He has also been awarded the Cutlers' Company prize and medal. He has been a student at the County Technical College, Wednesbury, for the past five years.

Research Progress

Improvement of Castings

BY RECORDER

MANUFACTURERS often have the choice, in producing a given component, either of making a casting close to the required shape or of forging roughly to size from ingot, billet or bar stock. The tolerances specified are frequently obtained by using subsequent machining operations, though there is a growing tendency to reduce this additional processing by improving dimensional accuracy in the casting or forging stages. Two of the main factors governing the choice of manufacturing method are: first, the properties needed in the product, and second, the ease with which the shape can roughly or exactly be produced by casting on the one hand or forging on the other.

Many alloys have been developed, however, that have useful as-cast properties but which are difficult to manipulate by normal mechanical working. Such materials usually have well-defined advantages, e.g. in cost, corrosion resistance and the like, though the tensile properties, even after heat-treatment, may be somewhat inferior to those of generally similar wrought alloys. Any improvement in the properties of castings that can be obtained at low cost is likely to be particularly advantageous, then, if applicable to these "casting" alloys. An investigation into the use of press forging for this purpose has been carried out at the Armour Research Foundation, Chicago, by A. H. Murphy, L. L. Clark and W. Rostoker[1] with promising results.

Preparation of Specimens

The materials employed were Al 356 (containing 7·03 per cent silicon, 0·33 per cent magnesium, 0·13 per cent titanium, 0·20 per cent iron), Al 220 (Al-9·8 per cent magnesium), and Mg AZ92 (9·2 per cent aluminium 2·0 per cent zinc, 0·18 per cent manganese). Plates 12·5×8×1 in. in each alloy were cast, and eight 1 in. square, 8 in. long specimens cut from each plate. Smooth, sound castings in the Mg AZ92 material were obtained using a copper chill. The reproducibility of properties from plate to plate, and with respect to position in the plate, was checked for a series of about 40 specimens and found to be reasonably consistent; the values obtained were similar to those encountered in commercial castings. The worst scatter appears to have arisen in elongation results for Al 220, since only 90 per cent of the values lay within the rather wide range 7-13·5 per cent elongation, but it is not stated whether or not the variations were systematic or random. Incidentally, all the tests were carried out on heat-treated samples, Al 356 being solution treated 1,000°F. (538°C.) for 12 hr.—water quench—age 300°F. (149°C.) for 4 hr., Al 220 solution treated 765°F. (407°C.) for 4 hr.—water quench, and Mg AZ92 solution treated 765°F. (407°C.) for 6 hr.—cycled to 665°F. (352°C.) for 2 hr.—cycled to 765°F. for 10 hr.—air quenched—age 500°F. (260°C.) for 4 hr.

Pressures Required

The power required to deform the alloys by up to 40 per cent at various temperatures up to 400°F. (204°C.) was next determined. The flat-faced pressing dies were maintained at the nominal deformation temperature to ensure isothermal conditions. A 1,000-ton press was used, the forging rate being about 0·5 in/min. The authors suggest that the required pressures should be influenced only slightly by pressing speed "within the practical range," though this seems rather doubtful considering the difference between the very slow rate they employed and the speeds available on most commercial presses.

For 1 in. square 8 in. long blocks of alloy Al 356, pressures of about 52,000, 40,000 and 35,000 lb/in² were required at 10 per cent deformation and forging temperatures of ambient conditions, 200°F. (93°C.) and 300°F. (149°C.) respectively. For 30 per cent deformation the values were approximately 70,000, 50,000 and 45,000 lb/in² respectively. The tendency for the pressure to rise substantially for deformations of 30-40 per cent was probably due to the absence of lubricant. The figures given above refer to the alloy in the solution-treated condition. The pressures needed when the specimens were aged prior to forging were considerably higher for otherwise similar conditions, though the difference became less as the forging temperature was increased. Even at the ageing temperature, however, the pressures required for aged samples were higher than those for solution treated bars, suggesting that the time of preheating at the forging temperature was of importance.

Alloy Al 220 required higher pressures than Al 356 at room temperature for the same deformation. Thus, for 10 per cent reduction in thickness a pressure of about 70,000 lb/in² was needed and at 30 per cent deformation about 120,000 lb/in². The magnesium alloy Mg AZ92 tended to fracture at low reductions at temperatures below 300°F. (149°C.). All work on this material was, therefore, carried out at a pressing temperature of 400°F. (204°C.). Here again, a difference in behaviour between aged and solution treated material was found, the latter requiring about 18,000 lb/in², the former about 22,000 lb/in² for 10 per cent deformation. At greater reductions than about 20 per cent, however, the aged specimens required slightly lower pressures than the solution treated samples.

Determination of Properties

Press-forged samples were next machined and the tensile properties determined. Where appropriate, an ageing heat-treatment was given to bars pressed in the solution-treated state. For the Al 356 alloy, the strength increased rapidly as the forging deformation increased to about 20 per cent. At higher reductions, the strength remained almost constant. The elongation values followed a similar pattern, but falling rather than rising. At 20 per cent deformation, then, the tensile strength had risen from about 35,000 lb/in² to about 41,000 lb/in², and the elongation had dropped from about 3·5 per cent to around 0·5 per cent. These results are not promising although, as Murphy *et al* point out, it makes possible the selective improvement of certain areas of a casting which could otherwise be improved only by heat-treating the whole component.

More useful results were given by the other two materials. Alloy 220, for instance, gave a tensile strength of 50,000 lb/in² at a reduction of 30 per cent, the "normal" value being about 32,000 lb/in². Here, the elongation fell only from about 14 per cent to 12 per cent. Even at 10 per cent deformation, the ultimate strength had risen to nearly 40,000 lb/in². Similarly, for the Mg AZ92 material the strength rose from 29,500 lb/in² to 35,000 lb/in², at a deformation of 20 per cent, no change in elongation (already low) being detected. In this alloy, the (0·01 per cent?) proof stress was strongly affected by press-forging to 20 per cent reduction, rising from 9,400 lb/in² to 16,200 lb/in². In neither case could the properties obtained by press-forging be achieved by heat-treatment.

Application of Results

The Paper is concluded by a description of the application of the results to the production of improved properties in a Mg AZ92 aircraft component. Beryllium-copper dies were

(*Continued on page* 478)

VANADIUM AND CHROMIUM ADDITIONS IMPROVE FORMING CHARACTERISTICS

New Titanium Alloy

A HEAT-TREATABLE all-beta titanium alloy has been produced by the Crucible Steel Company of America. The alloy has the great advantage of being readily formed in the so-called solution-treated or "soft" condition and then strengthened by simple thermal ageing treatments. The strengths obtainable with this alloy are higher than previously possible in titanium sheet materials.

The basis for the development of the new alloy B-120VCA was the need to stabilize titanium's high temperature beta structure down to room temperature in order to secure the advantages of beta's excellent formability. This led to the addition of a relatively large amount of alloy beta stabilizer elements, namely, 13 per cent vanadium and 11 per cent chromium. Though very formable because of its beta structure, this base was also potentially very hardenable because of its high alloy content.

Four per cent aluminium was then added for proper balance of the alloying elements, so that the structure stays all-beta during forming and/or during slow cooling, and ages to quite high strength levels at conveniently short times and low temperatures, but still does not over-age and become brittle or weak in service.

The resulting B-120VCA composition seems to be an ideal alloy balance to meet these difficult requirements. For example, annealing B-120VCA sheet with normal air cooling also solution quenches it to the soft formable condition. This, of course, greatly simplifies mill processing and shop fabricating. In this formable condition, it has a minimum yield strength of 120,000 lb/in^2. Ageing this formable B-120VCA from 20 hr. to 100 hr. in the 850°-950°F. range then strengthens it to the 170,000-200,000 lb/in^2 yield strength range, with good residual ductility. Even considerably higher strength values than these are possible with some reduction in ductility.

The alloy offers several unique combinations of properties, but, like all materials, it has limitations beyond which other materials are superior.

For the short time (approximately 1-2 min.) of the tensile test, B-120VCA has a comfortable strength-weight advantage over alternative materials up to at least 1,000°F. For a considerably longer test period, such as 500 hr., VCA has a strength-weight advantage up to at least 600°F., and this probably extends to 700°F., and possibly to 800°F. (beyond this time-temperature combination, VCA ages stronger and less ductile, so that careful testing is required to determine its suitability). Beyond this limit, the "DOD" alloys, C-135AMo, etc., are more suited.

The foregoing strength-weight advantage, plus B-120VCA's excellent formability and weld ductility, suggest a wide field of utility.

The alloy has the following advantages:—(1) excellent bendability and formability; (2) weldability; (3) heat-treatable to high strength levels with no special equipment required; (4) ageing characteristics not markedly affected by forming after "solution treatment"; (5) non-directional sheet and strip properties; (6) good flatness in sheet form; (7) low scratch sensitivity; (8) no evidence of shear cracking or delayed cracking; (9) high tolerance for hydrogen; (10) ability to be brazed; (11) cold-headability.

The physical properties of solution-treated / annealed material are: density, approximately 4·82 gm/c.c. (0·175 lb/in^3); specific heat, approximately 0·131 B.Th.U/lb/°F.; thermal expansion, $5{\cdot}2\times10^{-6}$/in/in/°F. (68°F.-200°F.); thermal conductivity, 3·90 B.Th.U/hr/ft^2/°F/ft.

As previously mentioned, formable B-120VCA is stable for long periods of time up to 600°F. At temperatures somewhat above this, long time ageing will cause some beta to transform to alpha plus intermetallic compounds, resulting in a marked increase in strength. The optimum ageing temperature appears to be 850° to 900°F. for times of 50 to 100 hr. for simple, single-step ageing. Double-step ageing sequences still being developed promise to lower the total ageing time to 10-20 hr.

Applications

The alloy is being tested in applications such as aircraft skins, stiffeners and other primary structural shapes requiring high strength for long times at temperatures up to at least 575°F. and optimum formability. Preliminary tests indicate that B-120VCA has no equal as a material of construction for honeycomb assembly. This alloy appears to be ideally suited for missile applications such as pressure tanks and casing skins, and structural members requiring excellent strength-weight ratio for a few hours up to 1,000°F. and shorter times up to 1,400°F. Since B-120VCA has exhibited excellent cold headability in many instances, it has a large potential in aircraft and missile rivets and bolts.

Standard Specifications

"Sheet Roof Coverings." Part 1: *Aluminium Corrugated Troughed Sheets (for Pitched Roofing and Vertical Cladding).* (*CP*143:1958.) *Price* 6*s.*

RECOMMENDATIONS for the use of aluminium alloy corrugated and troughed sheet for the roofing and cladding of buildings are provided by this publication. It applies to three main types of material: 3 in. pitch corrugated sheet, and troughed sheet of both symmetric and asymmetric profile.

Information is given on fixing accessories, contact with other materials, weathering, thermal insulation, fire resistance and condensation. Laying and fixing procedures are fully described, and there are details of suitable spacing for fastenings. Guidance is given on minimum pitch, end and side laps, and methods of fixing.

Tables covering a range of purlins or rail spacings provide the maximum recommended loading (including a 200 lb. concentrated load) applicable to various thicknesses of the three types of sheet. The tables enable the user to verify that the sheet chosen is suitable for his particular requirements; design loadings can be ascertained by reference to CP3, Chapter V.

The 21-page code concludes with an appendix which contains diagrams of sheet profiles, and tables setting out the properties and weights of sections. The appendix will prove helpful in the selection of sheet for special applications.

Copies of the above-mentioned standard may be obtained from the British Standards Institution, 2 Park Street, London, W.1.

Research Progress

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used for the forging, designed to give the final dimensions with a reduction of 20 per cent from the casting. The expected increase in strength was obtained and over 100 castings were treated in the dies without detectable wear of the tools occurring. For the cost of what amounts to little more than a warm coining operation, then, the whole or part of a casting may be given considerably enhanced properties. It is interesting that the improvements are similar to those often obtained by cold rolling wrought materials: the authors' views on the mechanism whereby the changes occurred would have enhanced the value of their Paper.

Reference

1 A. H. Murphy, L. L. Clark and W. Rostoker; Amer. Foundrymen's Soc., Preprint No. 58-34, 1958.

Industrial News *Home and Overseas*

Fords Crown

After many years of research and experiments, **Fords (Finsbury) Limited** recently introduced to the world of bottling an entirely new aluminium Crown Seal, to be known as the "Fords Crown." It is so new and so revolutionary that it is considered that its potential cannot be fully realized until the many users have had the opportunity to try it for themselves.

The shell of the crown makes a new use of aluminium. The seal embodies a new principle and sets new standards of hygiene and efficiency. We understand that a bottler can make it for himself on his own premises economically. This new device consists of a standard-sized aluminium alloy crown shell, with sealing compound used in place of the conventional cork liner. The compound is flowed-in and takes the form of a gasket. The compound is resilient and will not harden under pressure, heat or age. The crown is locked on to the rim of the bottle in the usual manner.

The makers claim a number of advantages for this new sealing, principal among them being that it is rustless, it provides consistent sealing, no cork dust, is unaffected by heat, it is easy to remove, and is a clean and hygienic seal. The Fords crown machine comprises the following units:—a shell-making press unit, with a single, replaceable tool; compound depositor unit; curing oven unit, and Fords "Synchro-Print" unit.

Postgraduate Foundry Course

As part of its postgraduate foundry course, the **University of Birmingham** is holding a short course dealing with the theoretical and practical aspects of structure in castings, from Monday, December 15, to Wednesday, December 17, next. The attendance fee for the course is two guineas. Further particulars are available on application to the Secretary, The Department of Industrial Metallurgy, The University of Birmingham, Birmingham, 15.

New London Office

In order to serve South-Eastern England, **Anti-Dust Services Ltd**, of Dudley, Worcs., have now opened an office at 27 Eastern Avenue, Wanstead, London, E.11, with the telephone number of Wanstead 3467. This office is under the control of Mr. A. A. Evans, sales manager of the London and the S.E. area.

Institute of Metals

It has been announced by the Institute of Metals that Dr. C. E. Birchenall (Associate Professor of Chemistry at Princeton University, U.S.A.) has accepted an invitation from the Metal Physics Committee of the Institute to lecture on **"The Oxidation of Metals at High Temperatures."** This lecture will be given at 6.30 p.m. on Thursday, January 15, 1959, at 17 Belgrave Square, London, S.W.1. Visitors will be welcome and no tickets are required.

Fuel Efficiency

Organized by the East Anglian Regional Advisory Council for Further Education, in conjunction with the National Industrial Fuel Efficiency Service, a one-day regional conference on **"The New Fuel Acts"** is to be held on January 6, 1959, at 10.30 a.m., at the University of Cambridge Engineering Laboratory.

An Enquiry from India

We have been approached by a firm in Madras which is interested in the establishment of the following industrial units in Southern India:—

(1) Electrolytic copper refinery with an annual capacity of 300 tons, for the manufacture of electrolytic wirebars from copper scraps, blister copper, etc.

(2) Copper rod rolling plant with a capacity of 10 tons per day of 8 hr.

(3) Wire drawing plant with a capacity of 2 tons per day of 8 hr.

(4) Four-high cold rolling mill for the manufacture of brass and copper sheets, with a capacity of 10 tons per day of 8 hr. Power supply is A.C. 440 volts, 3-phase, and 50 cycles.

Our enquirers would be interested to hear from suppliers of plant and machinery for the above schemes, and we shall be pleased to put British firms in touch with the Indian firm concerned.

Electric Melting Furnaces

On another page in this journal is announced the composition of the board of the newly-formed company **Birlec-Efco (Melting) Limited**. This company has been formed by Birlec Limited and Efco Limited for the design and supply of all types of electric melting furnaces, including vacuum melting furnaces, for the ferrous and non-ferrous metals industries, together with smelting furnaces and induction heating equipment. Its offices are at Westgate, Aldridge, Staffs.

Aluminium Tower

Recently constructed for a Government department, a 325 ft. high tower, built throughout of aluminium alloy, was designed, fabricated and erected by E. C. Payter and Company Ltd., of Tipton, in 26 working weeks. The aluminium alloy (H30WP) was supplied by **Reynolds T.I. Aluminium Limited.**

The tower is supported on four pins resting on a portal frame structure which forms the skeleton of an air-conditioned and dust-proof instrument room, 25 ft^2 and 25 ft. high, lined throughout with aluminium. The tower is 25 ft. by 13 ft. at the base, and tapers to 13 ft. by 13 ft. at the 72 ft. level. There are working platforms at 78 ft., 288 ft. and 300 ft. Access to all levels is provided by passenger lifts accommodating four people. The entire structure weighs some 50 tons, of which some 40 tons are aluminium alloy.

Improved Design

A basic improvement in the re-designed Meynell steam/water mixing valve is the introduction of a Monel metal clack, which now replaces the original cast nickel alloy clack. The function of the Monel metal clack is to close on to the Fluon seat in the steamway. This new material is said to provide a much greater working life and leads to obvious economies. The mixing valve control knob is now manufactured from aluminium, and finished in red. A further improvement is the introduction of phosphor-bronze leaf jets which permit a fine control of water throughout over a wide range of pressures.

Italian Copper Imports

According to the Central Statistical Office in Rome, Italy's imports of crude copper for smelting and refining in the first eight months of the year were 1,806·9 metric tons, worth 57,483,000 lire, of which 501·1 tons were imported temporarily.

Imports of unworked copper in slabs, ingots, shots and powder were 59,183·4 tons, worth 18,021,209,000 lire, of which 11,910·8 tons were imported temporarily. Main sources of supply were Britain 6,636 tons; Belgian Congo 11,573·2; Chile 8,755, and United States 15,095·3 tons.

New Group Member

It is announced that Ray-Heet (Infra-Red) Ltd. has recently become a member of the Vokes group of companies. It will trade under the new name of **Ray-Heet (Process Plant) Ltd.** This new addition to the Vokes group will now have available all the facilities of a modern factory and well-equipped research laboratories, together with a highly developed world-wide sales organization, thus enabling them to substantially widen the scope of their activities.

They are able to offer the following range of process plant:—degreasing, cleaning and chemical pre-treatment plant, either by dip-tanks or continuous spray systems; spray-booths, either dry-back or water wash, from 5 ft. up to 70 ft. long; paint dipping plant; electrostatic painting plant; flow-coating plant; infra-red ovens (gas-fired); convection ovens, either direct or indirect, heated by gas, oil, steam, or high pressure hot water; cooling tunnels reducing the cooling time after stoving; all forms of mechanical handling equipment required in connection with the above-mentioned plant; paint mixing and circulating equipment (but not spray guns, hoses, air regulators, pressure paint containers or compressors).

Sintered Friction Material

A change in the method of sale and distribution of their sintered friction material is announced by **Sintered Products Limited.** To streamline communications between supplier and user, the arrangements whereby Small and Parkes Ltd. act as sole distributors will be replaced as from January 1, 1959, by an arrangement enabling direct liaison between manufacturer and user.

Small and Parkes Ltd. will continue with the sale and distribution of sintered friction material, but will no longer act on an exclusive basis. Future sales will be directed by Mr. G. Wilson, sales manager, and technical sales and development matters will be dealt with by Mr. R. I. Blackwell, both of Sintered Products Ltd., and Mr. W. Kitchen, of Small and Parkes Ltd.

New paint shop at Uitenhage, South Africa, designed and manufactured by The Incandescent Group

Continuous Painting Installation

One of the most important projects in the £500,000 extension plan just completed for South African Motor Assemblers and Distributors at their works at Uitenhage, South Africa, was the building of a new paint shop which sets a new standard in body finishing practice. The complete paint shop was designed and manufactured by **The Incandescent Group,** manufacture and installation being the sole responsibility of the Incandescent Group (South Africa) (Pty.) Ltd.

Our photograph on this page is of the interior of the new paint shop showing (left) bonderizing, paint dip, and drain sections; (centre and right) spray booths and baking ovens. The main building of the new paint shop covers an area of approximately 60,000 ft^2, and is separate from the main assembly buildings. Working in conjunction with this job are a paint mix building 1,600 ft^2 in area and a paint store of the same dimensions.

Specialized Service

Recently formed to offer a specialized service to users of virtually every type of liquid fuel, particularly those operating hot water and central heating boilers, steam raising and process plant burning residual fuel oil, compression engines burning diesel/gas oil or residual fuel oil, and spark ignition engines burning petrol, **Combustion Chemicals Limited** offer a range of liquid fuel improvers, including "Desulfurol," "Dieselfur" and "Dieseladd."

Export of Scrap Metal

A notice has been issued by the Board of Trade in which is explained the current practice of the Board with regard to the issue of export licences for non-ferrous metal scraps, wastes and residues. Broadly speaking, the position is as follows:—

The Board are prepared to consider applications to export the following, where the applicant can satisfy the Board that he has the material in stock or can readily obtain supplies: (1) collected contaminated nickel silver; (2) certain nickel alloys, wastes and residues not normally used in the manufacture of steel or of non-ferrous alloys; (3) tungsten metal scrap; (4) molybdenum metal scrap.

Where the Board are satisfied that the applicant has the material in stock, or can readily obtain it, and has offered it to consumers in the United Kingdom who have declined to purchase it, the Board will also consider applications for the export of the following: (i) beryllium copper scrap; (ii) zinc wastes and residues; (iii) tantalum scrap and tantalum/cobalt scrap and residues; (iv) cobalt wastes and residues; (v) cadmium wastes and residues, and cadmium battery plates; (vi) germanium metal scrap; (vii) remelted zinc.

Whenever the Board consider that a surplus exists, the Board will be prepared to consider applications to export any non-ferrous metal scraps, wastes and residues. A marked fall in the price in the United Kingdom of a material may be evidence of a surplus.

In present circumstances, apart from minor exceptions, the Board will not normally licence the export of non-ferrous metal scrap, wastes and residues other than those referred to above. Further notices will be issued from time to time when it is considered necessary to amend the practice.

Correspondence or enquiries concerning the issue of licences should be addressed to Export Licensing Branch, Board of Trade, Gavrelle House, Bunhill Row, London, E.C.1, telephone Monarch 4071.

Forthcoming Meetings

December 8—Institute of Metals. Scottish Local Section. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank Crescent, Glasgow, C.2. "Some Factors Affecting the Performance of Condenser and Heat Exchange Tubes." P. T. Gilbert. 6.30 p.m.

December 9—Institution of Production Engineers. Doncaster Section. Technical College Hall, Doncaster. "Manufacture of Ball and Roller Bearings." 7 p.m.

December 9 — Institution of Production Engineers. Halifax and Huddersfield Section. Percival Whitley Technical College, Francis Street, Halifax. "Current Experimental Work with Sintered Oxide as a Cutting Tool." R. N. Cook. 7.30 p.m.

December 9 — Institution of Production Engineers. London Graduate Section. Institution of Production Engineers, 10 Chesterfield Street, London, W.1. "Investment Castings by Centrifugal Methods." I. L. Gwynn. 7.15 p.m.

December 10—Institute of Metal Finishing. Organic Finishing Group. British Institute of Management, Management House, 80 Fetter Lane, London, E.C.4. "Problems of a Jobbing Paint Finisher." W. S. Field. 6.30 p.m.

December 11 — Institute of Metals. Sheffield Local Section. Engineering Lecture Theatre, The University, St. George's Square, Sheffield, 1. "X-ray Microscopy." W. W. Nixon. 7.30 p.m.

December 11—Institute of Metals. Birmingham Local Section. College of Technology, Gosta Green, Birmingham, 4. "Some Trends in American Metallurgy." W. O. Alexander. 6.30 p.m.

December 11 — Liverpool Metallurgical Society. The Library, Department of Metallurgy, University of Liverpool, 146 Brownlow Hill, Liverpool, 3. "The Metallurgical Applications of High-Resolution Electron Miscroscopy." J. Nutting. 7 p.m.

December 11—North East Metallurgical Society. Cleveland Scientific and Technical Institution, Corporation Road, Middlesbrough. "Bearing Metals from the User's Point of View." R. J. Brown. 7.15 p.m.

December 11 — Southampton Metallurgical Society. Small Physics Lecture Theatre, The University Southampton. "Brazing." Mr. Beaton. 7.15 p.m.

December 11 — Institute of British Foundrymen. Bedfordshire and Hertfordshire Section. Town Hall, Luton. "Production of a Cylinder Head Casting." L. W. Bolton. 7.30 p.m.

December 12 — Society of Instrument Technology. Midland Section. Regent House, St. Philip's Place, Colmore Row, Birmingham, 3. "pH Measurement and Control." J. W. Broadhurst. 7 p.m.

Scrap Metal Merchants' Meeting

BIRMINGHAM was the venue of the half-yearly general meeting of the **National Association of Non-Ferrous Scrap Metal Merchants,** and on Wednesday last (December 3), at the Midland Hotel, Birmingham, the President of the Association, **Mr. R. O. Barnett,** presided over a well-attended meeting, and was supported by members of the Council. A meeting of the members of the Council was held prior to the general meeting.

In presenting his report, the President said that the Council had held the usual six meetings since June, five being held in London and one, that day, in Birmingham. The present membership of the Association is 316, which is one more than it was in June last. During the last six months seven firms had been elected to membership but, on the other hand, six had resigned, in the main due to adverse trading conditions, cessation of business, or changes in trading policy.

The report then continued as follows:—

"A considerable portion of the subject matter of my report has already been covered in the Monthly Bulletin, the object of which is to keep members informed of major items of interest to the trade. Many other important topics are constantly under review by the Council which can only be reported upon if positive conclusions are reached.

"It is not intended to organize a course of lectures at the City of London College in 1959. Four successive courses have already been held there, and the Council is of the opinion that Birmingham should be the venue for the next course. The arrangements are being made by the College of Technology. Members will be advised as soon as possible of details of this course.

"The attention of the Council was drawn to the inconvenience and wastage of time occasioned through Government depots or factories having been closed on days preceding and following public holidays. This matter was taken up with the Admiralty, Air Ministry and Ministry of Supply. In all three cases replies were received to the effect that the difficulties experienced by our members were understood, and a satisfactory solution was reached. The Admiralty and the Air Ministry have undertaken to insert in invitations to tender a notice of any dates or times on which inspection of material cannot be made. The Ministry of Supply forwarded a schedule of the holidays on which the Royal Ordnance Factories expect to be closed throughout the remainder of the current year.

"All information received from firms or organizations appertaining to the construction of plant for the elimination of smoke when burning cable has been inserted in the Bulletin from time to time. It is known that a number of members have followed up this information, and perhaps when this report is being discussed, some members present may be prepared to comment on the result of their enquiries.

"Mr. Henry Benson, C.B.E., F.C.A., of Cooper Brothers and Co., chartered accountants, has been conducting an enquiry on behalf of Lord Mills, the Minister of Power, into the methods adopted by the London Electricity Board for the disposal of scrap cable and into allegations which have been made regarding these matters. A number of members of the Council and representatives from member firms have been interviewed in private by Mr. Benson, and there is no doubt that he can be under no misapprehension as to the reasons for the objection of the trade to the present system of disposal. . . .

"The Association protested strongly against the decision of the Board of Trade in July last not to permit further exports of manganese bronze scrap. A number of members who had had their applications for licences refused, submitted appeals to the Board of Trade on the grounds that they had entered into contracts with overseas buyers which they felt it was important to honour. Representatives of the Joint Non-Ferrous Scrap Committee met officials of the Board of Trade and representatives from the British Bronze and Brass Ingot Manufacturers' Association and the Copper Smelters' Association to discuss this problem. The Board of Trade have now advised the Association that they are prepared to grant licences for the export of manganese bronze scrap to merchants who had valid contracts in force at the time their original applications for licences were submitted, and also provided they still have the material in stock. There must also be an undertaking that the material will be supplied in full compliance with all the conditions of the original contract, including those relating to price. The Board of Trade have pointed out that this granting of licences is restricted to firms who completed firm contracts in good faith at the time when applications for licences were submitted in the early part of 1958.

"It now seems apparent that the European Free Trade Area project will not become operative for some time. The Council has, therefore, been giving considerable thought to some method of impressing on the Government the unfairness of the present situation concerning exports of non-ferrous scrap, apart from proceeding through the normal Board of Trade channels. A meeting of the Association Export Committee recently met to give detailed consideration to this problem.

"The National Association of Waste Material Dealers in America have published their new Standard classification for Non-Ferrous Scrap Metals—Circular N.F.58, which supersedes Circular N.F.50. As reported recently in the December Bulletin, the B.I.R. were disappointed to note that the new American specification did not embody any of the B.I.R. recommendations. It is proposed, therefore, by B.I.R. to formulate an additional number of specifications to supplement the American list for the requirements of European consumers. It is hoped that this suggestion, when implemented, will result in a complete specification being available, suitable for international trading. The Americans have obviously primarily produced a list for their domestic usage.

"Mr. D. J. R. Austin, the President of the B.I.R. Non-Ferrous Metals Section, recently reported to the Council on the Congress in Paris which he attended in October. Details of this report were included in the November Bulletin, and from that report it would appear that B.I.R. is maintaining close liaison with The Organisation for European Economic Co-operation and General Agreement on Tariffs and Trade, as likewise are the member countries, with their respective Governments, to further the policy of freedom of trading in non-ferrous metals.

"The Association is frequently approached by Government Departments, nationalized industries and the police with regard to thefts of metal, and the Association has been of assistance in recovering some of the material in question. Members are urged to pay particular attention to security measures in order to minimize these regrettable occurrences.

"In the December Bulletin, members were advised of the interview which was arranged between Mr. Card, deputy supplies officer, and Mr. Rudken, sales sub-committee chairman of the British Transport Commission, which I attended, accompanied by Mr. M. N. Joseph, of your Council. Prior to this meeting, there had been considerable correspondence between the secretary and the British Transport Commission concerning the large credit granted in connection with the purchase of scrap metal on tender, in spite of the fact that the Commission's usual terms require payment immediately on receipt of invoice.

"During the course of the interview, it became apparent that the British Transport Commission did not consider themselves to be on the same footing as a Government Department, and they reserved for themselves the right to grant credit facilities as and when they thought fit. Their attitude was that as their main function was to sell transport, they were of the opinion that it was in order for them to grant credit facilities when selling scrap metals, and their decision in that respect would be influenced by such facts as the amount of transport business done with the British Transport Commission. The Council of the Association is still not in agreement with this attitude, as they are strongly of the opinion that all the tenderers should be placed on an equal footing. The only course left open to the Council after this interview was to advise all members of the position so that they could bear that in mind when making application for credit facilities.

"The Finance Committee recently met under the chairmanship of Mr. M. N. Joseph, in the absence of Mr. Wood, to review the financial position during the current year and to make a recommendation to the Council with regard to the amount of the membership subscription for 1958. The Finance Committee has recommended to the Council that the annual subscription for 1959 should remain at £9.

"In August, Mr. S. W. Platt decided that the time had come for him to resign from the Council, and this decision was received with regret by his colleagues. I would like to take this opportunity of expressing my personal thanks to Mr. Platt for the valuable work he has done for the Association, and in particular during the time when I have held office as President and Vice-President."

(Here, the President also expressed appreciation for assistance from the vice-president, members of the Council, etc.).

Metal Market News

THE early part of last week found rather depressing conditions all round, for Wall Street suffered a major recession, indeed, the setback was easily the worst experienced since the great uprising began in April last. Not unnaturally, quotations on the London Stock Exchange lost ground in sympathy, but on Wednesday there was a good recovery in New York just prior to Thanksgiving Day, and prices in London followed suit. There seems to be a fairly general idea now that the recovery in the United States is rather levelling off, and, in fact, improved activity in iron and steel has apparently halted. On the New York Commodity Exchange, activity in dealing in copper futures continues unimpaired, and last week's turnover was exceptionally heavy. On the London Metal Exchange, trading was reasonably active in all the metals, copper being outstanding with a turnover of 15,000 tons, which is rather above the average for business in this metal. Kerb dealing was also fairly active. Stocks of copper in L.M.E. warehouses were up by 125 tons at 6,221 tons, but whether the tide has really turned may be doubted, for the London price parity is well below New York and there is, therefore, no inclination to ship metal across the Atlantic. A feature of the market last week was the virtual elimination of the backwardation, and even signs of a return to a contango. With the Rhodesian strike over and better prospects for ending the Canadian stoppage, buyers of three months' copper are taking a much easier view of the forward position, and values have declined accordingly. However, some people feel that we are not yet out of the wood and that a premium for the cash position may return.

The acute weakness that developed in London last week touched off corresponding easiness in the American scrap market, so that it was not surprising to hear on Monday that the custom smelters had reduced by 25 points to 29·75 cents, but it remained for the real collapse to come on the following day, when the Board of Trade announced that it was open to receive offers for 7,500 tons of copper. Of this, some 3,000 tons would be available for the producers, but the remainder was on hand for consumers. The custom smelters dropped to 29·50 cents, and in Whittingon Avenue the three months' quotation collapsed to £219 10s. 0d. in the first ring, but things looked a little better in the afternoon. This proved to be the bottom for the week, but before the close of business on Wednesday the custom smelters had dropped to 29 cents and the export price was down to 28·50 cents to 28·75, the previous quotation being 29·50 cents. All things considered, the market took this selling very well, and the close was well above the lowest, for on Friday afternoon last cash was quoted at £228, while three months was 5s. higher at £228 5s. 0d. Actually, at midday the market opened at £230 and the settlement price was £229. On the week cash lost £5, while three months was £3 15s. 0d. lower.

While nothing definite is known, it is believed that the bulk of the 7,500 tons offered by the Board of Trade has been sold, and presumably it is not impossible that there may be some more to come. Of the other metals, tin was quiet, closing £2 down for cash at £758 and 10s. lower for three months at £761 10s. 0d. Zinc was pretty active, although trading was somewhat patchy. The turnover amounted to 8,300 tons, and on balance November was 5s. down and February 15s. off. Lead, at £75 prompt and £74 17s. 6d. forward, showed losses of £1 and £1 2s. 6d.

Birmingham

Little change has taken place in the metal-using industries in the Midlands. The recent improvement in sales of domestic appliances normally bought on hire purchase terms has been maintained, and there is a better demand for raw materials from manufacturers. On the other hand, a good deal of short time is being worked, and improvement seems unlikely until well into the New Year. The motor trade remains the mainstay in the list of metal-consuming trades, and the outlook is very encouraging. There has also been some improvement amongst makers of machine tools. This is attributed to lifting of restrictions in certain export markets. Builders of railway rolling stock are well situated for orders, and there is a good call for small metal fittings.

In the iron and steel industry, the existence of stocks deters users from entering the market with orders of a substantial nature. The re-rolling mills continue to work below capacity and there is a good deal of unemployment in the iron foundries, although the position has improved slightly compared with the position a few months ago. Sheets are selling steadily for the motor trade. Tube mills, although not operating to the maximum, have a fair amount of work with engineering and shipbuilding firms. Heavy castings and forgings are also in good demand.

New York

The copper market was steady last week-end. Custom smelters reported light activity, but producers indicated continued good sales for December. One leading producer source, an active seller overseas, said he looked for continued good producer sales through the first quarter of 1959. He believed the producer price would remain at 29 cents, at least through the first quarter of 1959, with recovery on the London Metals Exchange developing once the heaviness of copper supply is worked off—probably 10 days or so.

Tin was quiet and steady. Lead and zinc were quiet. Lead sales for the week were placed at 4,983 tons.

Civilian industry interest in high-temperature alloys and light metals has been reviving the U.S. titanium business, which has been in the doldrums since the sharp cutback a year ago in missiles and aircraft orders at a time when new facilities were just coming into production. This was stated here by Mr. G. B. Brown, vice-president, Mallory-Sharon Metals Corporation.

Prior to the autumn of 1957, the U.S. Government had reserved 90 per cent of titanium output for defence, but since has changed this to only 75 per cent.

Mr. Brown pointed out that a great deal of new interest in the lightweight metal is being revived in aircraft and missile, food processing, papermaking, marine, automotive, and other industries. He attributed part of that to the development of new titanium alloy metals which will withstand higher temperatures, to declining prices for the metal, and to improvements in methods of working it, as well as to a better selling job in the industry.

Latest reports on copper state that the domestic tone of this metal is steady, with fair business reported by custom smelters. Some copper sources said they regarded the recent setbacks in price as healthy, particularly the decline in London, which they described as "a shaking out of the more speculative purchasers of the metal, who apparently had overbought on the recent price rise."

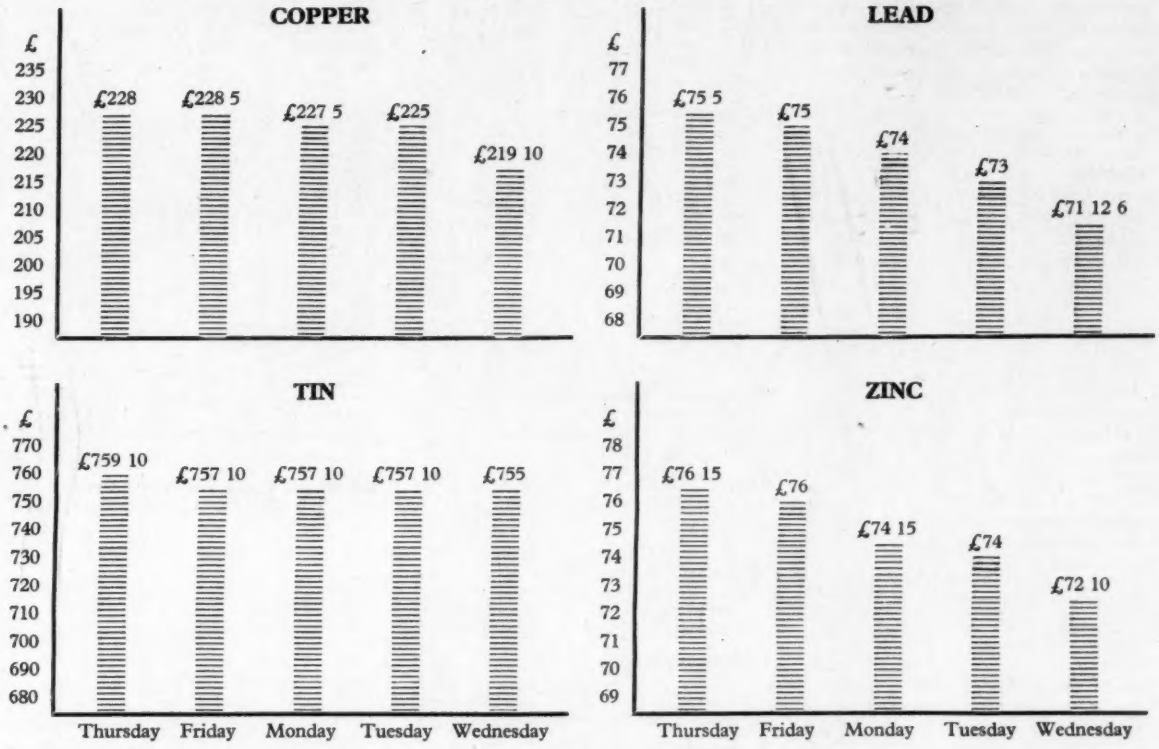
Western Germany

According to trade sources in Frankfurt, the West Germany lead market is in excellent shape. One leading producer reports that in the past eight to ten days he has expanded the volume of contracts for the coming year. Not a single customer had cut contracts, although some of these were sizeable. Fabricators are forecasting good business and full employment in the coming year, and there are rumours of an increase in production starting next January.

The zinc trade is also in a favourable position. Spot zinc is unavailable and sellers are holding back in the hope of better prices. One interesting factor is the emergence of Czechoslovakia and several other Communist bloc countries as buyers of considerable quantities of zinc during the past few weeks and, surprisingly, also as buyers of refined zinc and zinc dust, which they usually buy in Poland. Apparently, Poland is unable to deliver zinc in the desired quantities.

METAL PRICE CHANGES

LONDON METAL EXCHANGE, Thursday 27 November 1958 to Wednesday 3 December 1958



OVERSEAS PRICES

Latest available quotations for non-ferrous metals with approximate sterling equivalents based on current exchange rates

	Belgium fr/kg ≏ £/ton	Canada c/lb ≏ £/ton	France fr/kg ≏ £/ton	Italy lire/kg ≏ £/ton	Switzerland fr/kg ≏ £/ton	United States c/lb ≏ £/ton
Aluminium		22.50 185 17 6	210 182 15	375 217 10	2.50 209 0	26.80 214 10
Antimony 99.0			195 169 12 6	430 249 10		29.00 232 0
Cadmium			1,500 1,305 0			145.00 1,160 0
Copper						
Crude						
Wire bars 99.9				450 261 0		
Electrolytic	32.25 235 15	29.00 239 10	287 249 12 6		3.15 263 10 0	29.00 232 0
Lead		11.75 97 0	115 100 0	180 104 10	.95 79 10 0	13.00 104 0
Magnesium						
Nickel		70.00 578 5	1,205 1,048 7 6	1,300 754 0	7.50 627 2 6	74.00 592 0
Tin	107.25 784 0		928 807 7 6	1,460 846 17 6	9.00 752 10	99.50 796 0
Zinc						
Prime western		11.50 95 0 0				11.50 92 0
High grade 99.95		12.10 100 0 0				
High grade 99.99		12.50 103 5 0				
Thermic			107.12 93 2 6			
Electrolytic			115.12 100 2 6	179 103 17 6	.93 75 5	12.75 102 0

NON-FERROUS METAL PRICES

(All prices quoted are those available at 2 p.m. 3/12/58)

PRIMARY METALS

		£	s.	d.
Aluminium Ingots	ton	180	0	0
Antimony 99·6%	„	197	0	0
Antimony Metal 99%	„	190	0	0
Antimony Oxide	„	180	0	0
Antimony Sulphide Lump	„	190	0	0
Antimony Sulphide Black Powder	„	205	0	0
Arsenic	„	400	0	0
Bismuth 99·95%	lb.		16	0
Cadmium 99·9%	„		9	6
Calcium	„	2	0	0
Cerium 99%	„	16	0	0
Chromium	„		6	11
Cobalt	„		16	0
Columbite per unit			—	
Copper H.C. Electro	ton	219	10	0
Fire Refined 99·70%	„	218	0	0
Fire Refined 99·50%	„	217	0	0
Copper Sulphate	„	78	0	0
Germanium	grm.		—	
Gold	oz.	12	10	4½
Indium	„		10	0
Iridium	„	20	0	0
Lanthanum	grm.		15	0
Lead English	ton	71	12	6
Magnesium Ingots	lb.		2	5½
Notched Bar	„		2	10½
Powder Grade 4	„		6	3
Alloy Ingot, A8 or AZ91	„		2	8
Manganese Metal	ton	290	0	0
Mercury	flask	74	0	0
Molybdenum	lb.	1	10	0
Nickel	ton	600	0	0
F. Shot	lb.		5	5
F. Ingot	„		5	6
Osmium	oz.		nom.	
Osmiridium	„		nom.	
Palladium	„	5	15	0
Platinum	„	19	10	0
Rhodium	„	40	0	0
Ruthenium	„	15	0	0
Selenium	lb.		nom.	
Silicon 98%	ton		nom.	
Silver Spot Bars	oz.		6	4¾
Tellurium	lb.		15	0
Tin	ton	755	0	0
***Zinc**				
Electrolytic	ton		—	
Min 99·99%	„		—	
Virgin Min 98%	„	70	18	9
Dust 95/97%	„	109	0	0
Dust 98/99%	„	115	0	0
Granulated 99+%	„	95	18	9
Granulated 99·99+%	„	110	5	0

**Duty and Carriage to customers' works for buyers' account.*

INGOT METALS

Aluminium Alloy (Virgin)		£	s.	d.
B.S. 1490 L.M.5	ton	210	0	0
B.S. 1490 L.M.6	„	202	0	0
B.S. 1490 L.M.7	„	216	0	0
B.S. 1490 L.M.8	„	203	0	0
B.S. 1490 L.M.9	„	203	0	0
B.S. 1490 L.M.10	„	221	0	0
B.S. 1490 L.M.11	„	215	0	0
B.S. 1490 L.M.12	„	223	0	0
B.S. 1490 L.M.13	„	216	0	0
B.S. 1490 L.M.14	„	224	0	0
B.S. 1490 L.M.15	„	210	0	0
B.S. 1490 L.M.16	„	206	0	0
B.S. 1490 L.M.18	„	203	0	0
B.S. 1490 L.M.22	„	210	0	0

		£	s.	d.
†**Aluminium Alloys (Secondary)**				
B.S. 1490 L.M.1	ton	142	10	0
B.S. 1490 L.M.2	„	152	0	0
B.S. 1490 L.M.4	„	169	0	0
B.S. 1490 L.M.6	„	186	0	0

†Average selling prices for mid October

***Aluminium Bronze**				
BSS 1400 AB.1	ton	227	0	0
BSS 1400 AB.2	„	238	0	0
***Brass**				
BSS 1400-B3 65/35	„	147	0	0
BSS 249	„		—	
BSS 1400-B6 85/15	„		—	
***Gunmetal**				
R.C.H. 3/4% ton	„		—	
(85/5/5/5)	„	183	0	0
(86/7/5/2)	„	192	0	0
(88/10/2/1)	„	241	0	0
(88/10/2/½)	„	251	0	0
Manganese Bronze				
BSS 1400 HTB1	„	184	0	0
BSS 1400 HTB2	„		—	
BSS 1400 HTB3	„		—	
Nickel Silver				
Casting Quality 12%	„		nom.	
„ „ 16%	„		nom.	
„ „ 18%	„		nom.	
***Phosphor Bronze**				
B.S. 1400 P.B.1 (A.I.D. released)	„	274	0	0
B.S. 1400 L.P.B.1	„	216	0	0
Phosphor Copper				
10%	„	244	0	0
15%	„	248	0	0

**Average prices for the last week-end.*

Phosphor Tin				
5%	ton		—	
Silicon Bronze				
BSS 1400-SB1	„		—	
Solder, soft, BSS 219				
Grade C Tinmans	„	353	6	0
Grade D Plumbers	„	288	0	0
Grade M	„	390	6	0
Solder, Brazing, BSS 1845				
Type 8 (Granulated)	lb.		—	
Type 9 „	„		—	
Zinc Alloys				
Mazak III	ton	103	10	0
Mazak V	„	107	10	0
Kayem	„	113	10	0
Kayem II	„	119	10	0
Sodium-Zinc	lb.		2	6

SEMI-FABRICATED PRODUCTS

Prices of all semi-fabricated products vary according to dimensions and quantities. The following are the basis prices for certain specific products.

Aluminium			£	s.	d.
Sheet 10 S.W.G.	lb.			2	8½
Sheet 18 S.W.G.	„			2	10½
Sheet 24 S.W.G.	„			3	1½
Strip 10 S.W.G.	„			2	8½
Strip 18 S.W.G.	„			2	9½
Strip 24 S.W.G.	„			2	11
Circles 22 S.W.G.	„			3	2½
Circles 18 S.W.G.	„			3	1½
Circles 12 S.W.G.	„			3	0½
Plate as rolled	„			2	8
Sections	„			3	2
Wire 10 S.W.G.	„			2	11½
Tubes 1 in. o.d. 16 S.W.G.	„			4	1

Aluminium Alloys		£	s.	d
BS1470. HS10W.	lb.			
Sheet 10 S.W.G.	„		3	1
Sheet 18 S.W.G.	„		3	3½
Sheet 24 S.W.G.	„		3	11
Strip 10 S.W.G.	„		3	1
Strip 18 S.W.G.	„		3	2½
Strip 24 S.W.G.	„		3	10½
BS1477. HP30M. Plate as rolled	„		2	11
BS1470. HC15WP.				
Sheet 10 S.W.G.	„		3	9½
Sheet 18 S.W.G.	„		4	2
Sheet 24 S.W.G.	„		5	0½
Strip 10 S.W.G.	„		3	10½
Strip 18 S.W.G.	„		4	2
Strip 24 S.W.G.	„		4	9½
BS1477. HPC15WP. Plate heat treated	„		3	6½
BS1475. HG10W. Wire 10 S.W.G.	„		3	10½
BS1471. HT10WP. Tubes 1 in. o.d. 16 S.W.G.	„		5	0½
BS1476. HE10WP. Sections	„		3	1½
Beryllium Copper				
Strip	„	1	4	11
Rod	„	1	1	6
Wire	„	1	4	9
Brass Tubes	„		1	9½
Brazed Tubes	„		—	
Drawn Strip Sections	„		—	
Sheet	ton		—	
Strip	„	249	0	0
Extruded Bar	lb.		1	11¾
Extruded Bar (Pure Metal Basis)	„		—	
Condenser Plate (Yellow Metal)	ton	184	0	0
Condenser Plate (Naval Brass)	„	195	0	0
Wire	lb.		2	7½
Copper Tubes	lb.		2	2¾
Sheet	ton	255	5	0
Strip	„	255	5	0
Plain Plates	„		—	
Locomotive Rods	„		—	
H.C. Wire	„	279	5	0
Cupro Nickel				
Tubes 70/30	lb.		3	6¼
Lead Pipes (London)	ton	115	10	0
Sheets (London)	„	113	5	0
Tellurium Lead	„	£6 extra		
Nickel Silver				
Sheet and Strip 7%	lb.		3	8
Wire 10%	„		4	2¾
Phosphor Bronze				
Wire	„		4	0
Titanium (1,000 lb. lots)				
Billet over 4″ dia.-18″ dia.	lb.	63/-		64/-
Rod 4″ dia.-·250″ dia.	„	75/-		112/-
Wire under ·250″ dia.-·036″ dia.	„	146/-		222/-
Sheet 8′ × 2′ × ·250″-·010″ thick	„	88/-		157/-
Strip ·048″-·003″ thick	„	100/-		350/-
Tube (representative gauge)	„			300/-
Extrusions	„			120/-
Zinc Sheets, English destinations	ton	107	10	0
Strip	„		nom.	

Scrap Metal Prices

Merchants' average buying prices delivered, per ton, 2/12/58.

	£
Aluminium	
New Cuttings	142
Old Rolled	120
Segregated Turnings	90
Brass	
Cuttings	138
Rod Ends	132
Heavy Yellow	109
Light	104
Rolled	128
Collected Scrap	107
Turnings	125
Copper	
Wire	195
Firebox, cut up	186
Heavy	182
Light	177
Cuttings	195
Turnings	170
Braziery	146
Gunmetal	
Gear Wheels	175
Admiralty	175
Commercial	151
Turnings	146
Lead	
Scrap	64
Nickel	
Cuttings	—
Anodes	500
Phosphor Bronze	
Scrap	151
Turnings	146
Zinc	
Remelted	60
Cuttings	46
Old Zinc	35

The latest available scrap prices quoted on foreign markets are as follow. (The figures in brackets give the English equivalents in £1 per ton):—

West Germany (D-marks per 100 kilos):		
Used copper wire	(£187.0.0)	215
Heavy copper	(£182.15.0)	210
Light copper	(£156.12.6)	180
Heavy brass	(£111.7.6)	128
Light brass	(£87.0.0)	100
Soft lead scrap	(£58.5.0)	67
Zinc scrap	(£38 5.0)	44
Used aluminium unsorted	(£87.0.0)	100
France (francs per kilo):		
Copper	(£213.2.6)	245
Heavy copper	(£213.2.6)	245
Light brass	(£143.10.0)	165
Zinc castings	(£61.0.0)	70
Lead	(£86.2.6)	99
Tin	—	
Aluminium	(£117.10.0)	135
Italy (lire per kilo):		
Aluminium soft sheet clippings (new)	(£194.7.6)	335
Aluminium copper alloy	(£124.15.0)	215
Lead, soft, first quality	(£85.5.0)	147
Lead, battery plates	(£51.0.0)	88
Copper, first grade	(£208.17.6)	360
Copper, second grade	(£197.5.0)	340
Bronze, first quality machinery	(£203.0.0)	350
Bronze, commercial gunmetal	(£174.0.0)	300
Brass, heavy	(£142.2.6)	245
Brass, light	(£130.10.0)	225
Brass, bar turnings	(£133.10.0)	230
New zinc sheet clippings	(£61.0.0)	105
Old zinc	(£46.15.0)	80

Financial News

British Aluminium Company

Events leading up to the present position regarding the future of The British Aluminium Company Limited have been carried a step further by the issue of two statements, one from Tube Investments Limited and the other from Alcoa. On Monday evening last T.I. released the text of its letter of intent, dated November 5. The letter referred to a merging into British Aluminium "through its existing entity and management" of T.I.'s aluminium interests, and added: "We are prepared to make an offer to your Ordinary shareholders to acquire their shares, either for cash or for cash and shares, on a price basis which would be attractive to them and not least in terms of market price."

The letter had been written before Viscount Portal of Hungerford, chairman of British Aluminium, and Mr. Cunliffe left for Canada because "we do not believe it would be in the interests of your shareholders that you should enter into any commitments which might adversely affect the offer we would make to your shareholders."

It was added that T.I. could provide any finance needed by the British Aluminium group.

Alcoa's statement said that since June, 1958, when negotiations with British Aluminium started, it had made clear that it had no desire or intention of acquiring control of British Aluminium, and it still had no such desire or intention.

"Alcoa's reason for agreeing to subscribe for the unissued shares of British Aluminium was its desire to participate to a greater extent than heretofore in the development of the aluminium markets of the world, and in the production facilities needed in order to serve those markets," the statement said.

"It recognized that British Aluminium had these same objectives, and it was felt that these objectives could best be achieved by a closer association between the two companies."

If Treasury consent were received, Alcoa intended to ask for "a representation of not more than three persons out of a proposed total of 15 on the board of British Aluminium, to leave the board and management just as free as in the past, and to give full support to the board in carrying out its present plans for the development of its interests at home and overseas."

Trade Publications

Forging of Difficult Materials.—Daniel Doncaster and Sons Ltd., Penistone Road, Sheffield, 6.

With the introduction of newer metals, such as titanium, into the aircraft, chemical, and nuclear fields, it became necessary to devise methods of working them which took account of their peculiar properties. One of the first companies to undertake the forging of titanium was Daniel Doncaster and Sons Ltd., who have now issued a well illustrated brochure with the object of assisting firms in industries now considering the application of the newer metals into their own particular products. Doncasters are now successfully forging on a production basis such metals as titanium, Nimonic, zirconium, aluminium bronze, heat-resisting alloys, etc., and in this brochure the company provides a number of examples of the results of their research and experience in these fields.

Industrial Tack Rags. — Anti-Dust Services Ltd., Dudley, Worcs.

This booklet describes and explains the "Taccy Rags" made by this company, giving the reasons for the high efficiency of these rags in preparing surfaces during the finishing processes and the economical advantages to be gained by using dust-absorbing wipers of the adhesive type to ensure perfect finishes on industrial and consumer products.

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THE STOCK EXCHANGE

Prices Recovered From Temporary Setback, Subsequently Becoming Rather Irregular

ISSUED CAPITAL •	AMOUNT OF SHARE	NAME OF COMPANY	MIDDLE PRICE 2 DECEMBER	+RISE —FALL	DIV. FOR LAST FIN. YEAR	DIV. FOR PREV. YEAR	DIV. YIELD	1958 HIGH	1958 LOW	1957 HIGH	1957 LOW
£	£				Per cent	Per cent					
4,435,792	1	Amalgamated Metal Corporation ...	24/3		9	10	7 8 6	24/9	17/6	28/3	18/–
400,000	2/–	Anti-Attrition Metal	1/7½		4	8½	4 18 6	1/9	1/3	2/6	1/6
38,305,038	Stk. (£1)	Associated Electrical Industries ...	57/9xd	+2/9	15	15	5 3 9	58/–	46/6	72/3	47/9
1,590,000	1	Birfield	57/3	—1/3	15	15	5 4 9	62/4½	46/3	70/–	48/9
3,196,667	1	Birmid Industries	64/6	+6d.	17½	17½	5 8 6	77/6	55/3	80/6	55/9
5,630,344	Stk. (£1)	Birmingham Small Arms	35/3	+9d.	11	10	6 4 9	37/3	23/9	33/–	21/9
203,150	Stk. (£1)	Ditto Cum. A. Pref. 5%	15/–		5	5	6 13 3	16/1½	14/7½	16/–	15/–
350,580	Stk. (£1)	Ditto Cum. B. Pref. 6%	17/1½		6	6	7 0 3	17/4½	16/6	19/–	16/6
500,000	1	Bolton (Thos.) & Sons	26/9	+6d.	10	12½	7 9 6	28/9	24/–	30/3	28/9
300,000	1	Ditto Pref. 5%	15/–		5	5	6 13 3	16/–	15/–	16/9	14/3
160,000	1	Booth (James) & Co. Cum. Pref. 7%	20/–		7	7	7 0 0	20/4½	19/–	22/3	18/9
9,000,000	Stk. (£1)	British Aluminium Co.	66/3	+8/9	12	12	3 12 6	72/6	36/6	72/–	38/3
1,500,000	Stk. (£1)	Ditto Pref. 6%	19/9	+3d.	6	6	6 1 6	20/–	18/4½	21/6	18/–
15,000,000	Stk. (£1)	British Insulated Callender's Cables	50/6xd	+6d.	12½	12½	4 19 0	52/–	38/9	55/–	40/–
17,047,166	Stk. (£1)	British Oxygen Co. Ltd., Ord. ...	43/9	+1/9	10	10	4 11 6	47/–	28/3	39/–	29/6
600,000	Stk. (5/–)	Canning (W.) & Co.	24/3		25+ *2½C	25	5 3 0	24/6	19/7½	24/6	19/3
60,484	1/–	Carr (Chas.)	1/6		25	25	11 13 3	2/3	1/4½	3/6	2/1½
150,000	2/–	Case (Alfred) & Co. Ltd.	5/–		25	25	10 0 0	5/3	4/–	4/6	4/–
555,000	1	Clifford (Chas.) Ltd.	21/–		10	10	9 10 6	21/–	16/–	20/6	15/9
45,000	1	Ditto Cum. Pref. 6%	15/6		6	6	7 14 9	16/–	15/–	17/6	16/–
250,000	2/–	Coley Metals	3/3	+3d.	20	25	12 6 3	4/6	2/6	5/7½	3/9
8,730,596	1	Cons. Zinc Corp.†	58/6	+2/–	18¾	22½	6 8 3	58/9	41/–	92/6	49/–
1,136,233	1	Davy & United	81/6	+1/6	20	15	4 18 0	81/6	45/9	60/6	42/6
2,750,000	5/–	Delta Metal	24/6		30	*17½	6 2 6	25/–	17/7½	28/6	19/–
4,160,000	Stk. (£1)	Enfield Rolling Mills Ltd.	34/9xd		12½	15B	7 3 9	38/–	22/9	38/6	25/–
750,000	1	Evered & Co.	28/–		15Z	15	7 2 9	28/9	26/–	52/9	42/–
18,000,000	Stk. (£1)	General Electric Co.	36/–	+1/3	10	12½	5 11 0	39/6	29/6	59/–	38/–
1,500,000	Stk. (10/–)	General Refractories Ltd.	35/9		20	17½	5 12 0	39/3	27/3	37/–	26/9
401,240	1	Gibbons (Dudley) Ltd.	67/6		15	15	4 9 0	67/6	61/–	71/–	53/–
750,000	5/–	Glacier Metal Co. Ltd.	7/–		11½	11½	8 4 3	8/3	5/–	8/1½	5/10½
1,750,000	5/–	Glynwed Tubes	16/4½	—3d.	20	20	6 2 0	18/1½	12/10½	18/–	12/6
5,421,049	10/–	Goodlass Wall & Lead Industries ...	29/–	+9d.	13‖	18Z	4 9 9	28/3	17/3	37/3	28/9
342,195	1	Greenwood & Batley	55/–		20	17½	7 5 6	55/–	45/–	50/–	46/–
396,000	5/–	Harrison (B'ham) Ord.	15/9		*15	*15	4 15 3	15/9	11/6	16/9	12/4½
150,000	1	Ditto Cum. Pref. 7%	19/9		7	7	7 1 9	19/9	18/4½	22/3	18/7½
1,075,167	5/–	Heenan Group	7/4½		10	10‡	6 15 6	9/7	6/9	10/4½	6/9
236,953,260	Stk. (£1)	Imperial Chemical Industries ...	35/9	+1/–	12Z	10	4 9 6	36/3	27/7½	46/6	36/3
33,708,769	Stk. (£1)	Ditto Cum. Pref. 5%	17/–	+3d.	5	5	5 17 9	17/1½	16/–	18/6	15/6
14,584,025	••	International Nickel	155	+6½	$2.60	$3.75	2 19 6	169	132¾	222	130
430,000	5/–	Jenks (E. P.), Ltd.	8/10½	+1½d.	27½φ	27½	7 15 0	9/–	6/7½	18/10½	15/1½
300,000	1	Johnson, Matthey & Co. Cum. Pref. 5%	15/7½	—7½d.	5	5	6 8 0	16/9	15/–	17/–	14/6
3,987,435	1	Ditto Ord.	45/6	—6d.	10	10	4 8 0	47/–	36/6	58/9	40/–
600,000	10/–	Keith, Blackman	28/9	+1/3	17½	15	6 1 9	28/3	15/–	21/9	15/–
160,000	4/–	London Aluminium	5/1½		10	10	7 16 0	5/1½	3/–	6/9	3/6
2,400,000	1	London Elec. Wire & Smith's Ord. ...	60/6	+6d.	12½	12½	4 2 9	64/6	39/9	54/6	41/–
400,000	1	Ditto Pref.	23/7½	—3d.	7½	7½	6 7 0	24/3	22/–	25/3	21/9
765,012	1	McKechnie Brothers Ord.	45/–	+2/–	15	15	6 13 3	45/–	32/–	48/9	37/6
1,530,024	1	Ditto A Ord.	44/–	—6d.	15	15	6 16 3	45/–	30/–	47/6	36/–
1,108,268	5/–	Manganese Bronze & Brass	13/1½	—4½d.	20	27½‡	7 12 6	14/1½	8/9	21/10½	7/6
50,628	6/–	Ditto (7½% N.C. Pref.)	6/–		7½	7½	7 10 0	6/3	5/6	6/6	5/–
13,098,855	Stk. (£1)	Metal Box	64/–	+1/6	11	11	3 8 9	64/–	40/6	59/–	40/3
415,760	Stk. (2/–)	Metal Traders	9/–	+3d.	50	50	11 2 3	9/–	6/3	8/–	6/3
160,000	1	Mint (The) Birmingham	20/–		10	10	10 0 0	22/9	19/–	25/–	21/6
80,000	5	Ditto Pref. 6%	70/6		•	6	8 10 3	83/6	70/6	90/6	83/6
3,705,670	Stk. (£1)	Morgan Crucible A	43/3	+1/–	10	10	4 12 6	42/10½	34/–	54/–	35/–
1,000,000	Stk. (£1)	Ditto 5½% Cum. 1st Pref. ...	17/6		5½	5½	6 5 9	17/9	17/–	19/3	16/–
2,200,000	Stk. (£1)	Murex	53/10½	+1/10½	17½	20	6 10 0	58/9	47/9	79/9	57/–
468,000	5/–	Ratcliffs (Great Bridge)	10/6		10	10	4 5 3	11/1½	6/10½	8/–	6/10½
234,960	10/–	Sanderson Bros. & Newbould ...	27/3	+2/9	20	27½D	7 6 9	27/–	24/6	41/–	24/9
1,365,000	Stk. (5/–)	Serck	18/–	+3d.	15	17½	4 2 3	17/9	11/–	18/10½	11/6
6,698,586	Stk. (£1)	Stone-Platt Industries	43/6	—6d.	15	12½	6 18 0	44/–	22/6	33/4½	22/7½
2,928,963	Stk. (£1)	Ditto 5½% Cum. Pref.	16/3	+3d.	5½	5½	6 15 6	16/3	12/7½	14/–	12/9
14,494,862	Stk. (£1)	Tube Investments Ord.	77/6	+9d.	17½	15	4 10 3	78/9	48/4½	70/9	50/6
41,000,000	Stk. (£1)	Vickers	34/9	+6d.	10	10	5 15 0	36/3	28/9	46/–	29/–
750,000	Stk. (£1)	Ditto Pref. 5%	15/6		5	5	6 9 0	15/9	14/3	18/–	14/–
6,863,807	Stk. (£1)	Ditto Pref. 5% tax free	22/–		*5	*5	7 0 3A	23/–	21/3	24/9	20/7½
2,200,000	1	Ward (Thos. W.), Ord.	82/3	+9d.	20	15	4 17 3	87/3	70/9	83/–	64/–
2,666,034	Stk. (£1)	Westinghouse Brake	42/3	—9d.	10	18P	4 14 9	43/6	32/6	85/–	29/1½
225,000	2/–	Wolverhampton Die-Casting ...	9/9	—3d.	30	25	6 3 0	10/1½	7/–	10/1½	7/–
591,000	5/–	Wolverhampton Metal	21/–	—3d.	27½	27½	6 11 0	22/9	14/9	22/3	14/9
78,465	2/6	Wright, Bindley & Gell	4/6		20	17½E	11 2 3	4/10½	2/9	3/9	2/7½
124,140	1	Ditto Cum. Pref. 6%	13/–		6	6	9 4 6	13/–	11/3	12/6	11/3
150,000	1/–	Zinc Alloy Rust Proof	2/9		27	40D	9 16 3	3/1½	2/7½	5/–	2/9

*Dividend paid free of Income Tax. †Incorporating Zinc Corpn. & Imperial Smelting. **Shares of no Par Value. ‡ and 100% Capitalized issue. • The figures given relate to the issue quoted in the third column. A Calculated on £7 14 6 gross. Y Calculated on 11½% dividend. ‖Adjusted to allow for capitalization issue. E for 15 months. P and 100% capitalized issue, also "rights" issue of 2 new shares at 35/– per share for £3 stock held. D and 50% capitalized issue. Z and 50% capitalized issue. B equivalent to 12½% on existing Ordinary Capital after 100% capitalized issue. φ And 100% capitalized issue. X Calculated on 17½%. C Paid out of Capital Profits.